1967

A proposed system for displaying accessing techniques to library users in the field of metallurgy

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A PROPOSED SYSTEM FOR DISPLAYING ACCESSING TECHNIQUES TO LIBRARY USERS IN THE FIELD OF METALLURGY

by

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A THESIS

Presented to the Graduate Faculty

of Lehigh University

in Candidacy for the Degree of

Master of Science

in the

Information Sciences

Lehigh University

1967

This thesis is accepted and approved in partial fulfillment of the requirements for the degree of Master of Science.

May 25, 1967
(date)

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ACKNOWLEDGEMENTS

The author wishes to express his indebtedness to Professor Robert S. Taylor for guidance and assistance, to Miss. Anne Rayan for aiding in the typing of the network frames, and to his wife Joan for graciously accepting the growing physical presence of this project in our home.

This research was supported by the Air Force Office of Aerospace Research under grants AF-AFOSR-724-65 and AF-AFOSR-724-66.

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ABSTRACT

Undergraduate engineering students are likely to be totally unaware of the practical information problems that face the practicing engineer. In order to prevent the waste of engineering talent that this situation inevitably causes, student engineers should receive some sort of training in information management. However, lectures alone will not suffice for this purpose because good information habits, like good study habits, must be self-taught.

The system described here, if properly implemented, might be used to help student engineers teach themselves how to access an information store, such as a library, and, in particular, how to specify a search request. Essentially, the system presents the user with subject headings like those found in the library subject catalog, except that diagrams rather than the usual cards are displayed. The user is thus enabled to see more of the cross-reference structure at one glance than he can in the conventional card file. From these maps the user can reach bibliographic lists and the tables of contents of pertinent reference materials. Provision is made for browsing. It is suggested that the system be implemented by an addressable microfilm display device with simple controls and a capability for producing hard copies of frames viewed if desired by the user.

INTRODUCTION

As reported by the Panel on Objectives of the Conference on Information Sources, Systems, and Media in Engineering Education held at Lehigh University in May of 1966,[1] many engineers receive information almost exclusively <u>via</u> the "often passive and barely conscious process" of conversing with colleagues, observing working operations, and occasional (unorganized) reading. The incomplete, obsolete, or even inaccurate information thus obtained, if not supplemented, updated, or corrected through an "aggressive consciously planned systematic information acquisition process," often results in wasted effort such as duplication of the work of others. The Panel points out that this disturbing situation is caused by a lack, in engineering curricula, of instruction in the value and the method of obtaining information in systematic fashion.

Now good information-gathering habits, like good study habits, are based upon individual diligence in observation and emulation of good examples. Presumably the motive for acquiring such habits is the desire to achieve the favorable results obtainable by people who have already acquired these habits. In particular, a recent study[2] shows that the incentive for using (or re-using) any given information source is based upon the expectancy of receiving useful information <u>easily</u>. In fact, <u>ease</u> of obtaining information was found to be of relatively greater importance to the users polled in this study than either <u>amount</u> or <u>quality</u> of information obtained.[3] Thus, it appears that the principal motive for acquiring good information habits is that it will become easier to obtain needed information.

However, while the student engineer has ample evidence of the need for having good study habits, he has almost no evidence of any need for acquiring good information habits. The reason for the latter is simple. Any time a student engineer needs information, his professor either knows the answer himself or can tell him precisely where to look it up; the student never learns <u>how to know</u> where to look it up. In the words of the ASEE/Lehigh Conference Panel on Objectives:

> .... engineering education, particularly at the undergraduate level, does not adequately convey the degree to which needed information is often <u>not</u> conveniently at hand. In contrast to the information situation prevailing in professional engineering practice -- the constant seeking for necessary but difficult-to-find information -- much of the student's work requires no search for information. In [engineering] practice, information sources and the manner of obtaining access are unknown -- the information wanted may not even exist. For students, however, if needed information is not given with the problems, the specific sources (handbooks, books of tables) needed are usually clearly announced....[4]

In addition, libraries and similar information services are not designed to serve the engineer's daily requirements for information. Hence he must rely on colleagues and other informal sources about which the student knows nothing because he has never had to search beyond the college library (if, indeed, that far). Thus, the student is typically unaware that there is an information-gathering problem, much less that he needs to acquire skills and good habits with respect to solving this problem as it will later inevitably affect his professional engineering tasks.

Accordingly, the Panel recommends instituting a program, principally aimed at undergraduate engineers, of education in the importance and skills of information management, including the use and usefulness of all information media and systems concerned with literature and data.[5]

In consideration of the foregoing, the system outlined in this paper was designed to be a supplement to classroom instruction in information management. It is intended to enable a student engineer to teach himself -- by a species of programmed instruction -- (1) what information sources are available in his own area of interest and in related fields; (2) what kind of information can be obtained from each type of source and how the information in various sources is related, so that each source may be used to best advantage; and (3) the value and method of specifying and narrowing a search request so as to obtain optimum results, including how to browse purposefully (how to increase the probability of serendipity). In particular, the system is designed to enable the engineering student to teach himself the value and method of using an access mechanism (here a variation on the subject card file) to an information store (here a selected sample of reference materials in the technology of Metallurgy).

Through this example the student engineer is expected to realize that information can be obtained more easily by the person who is aware of the existence and proper use of various access mechanisms than by the person who has an unsystematic approach to information gathering. Once this principle has become apparent to him, the student can then be expected gradually to compile his own list of access mechanisms to the information in his special discipline as well as steadily to sharpen his technique in using them. In the process he will become aware of the types of information to which different access techniques apply -- and to which none (as yet) apply. Thus, he will be better prepared to meet the practical information problems that will arise daily on the job.

In view of the rapidly changing state-of-the-art of addressable display devices, the discussion of the system's physical implementation is limited to general comments.

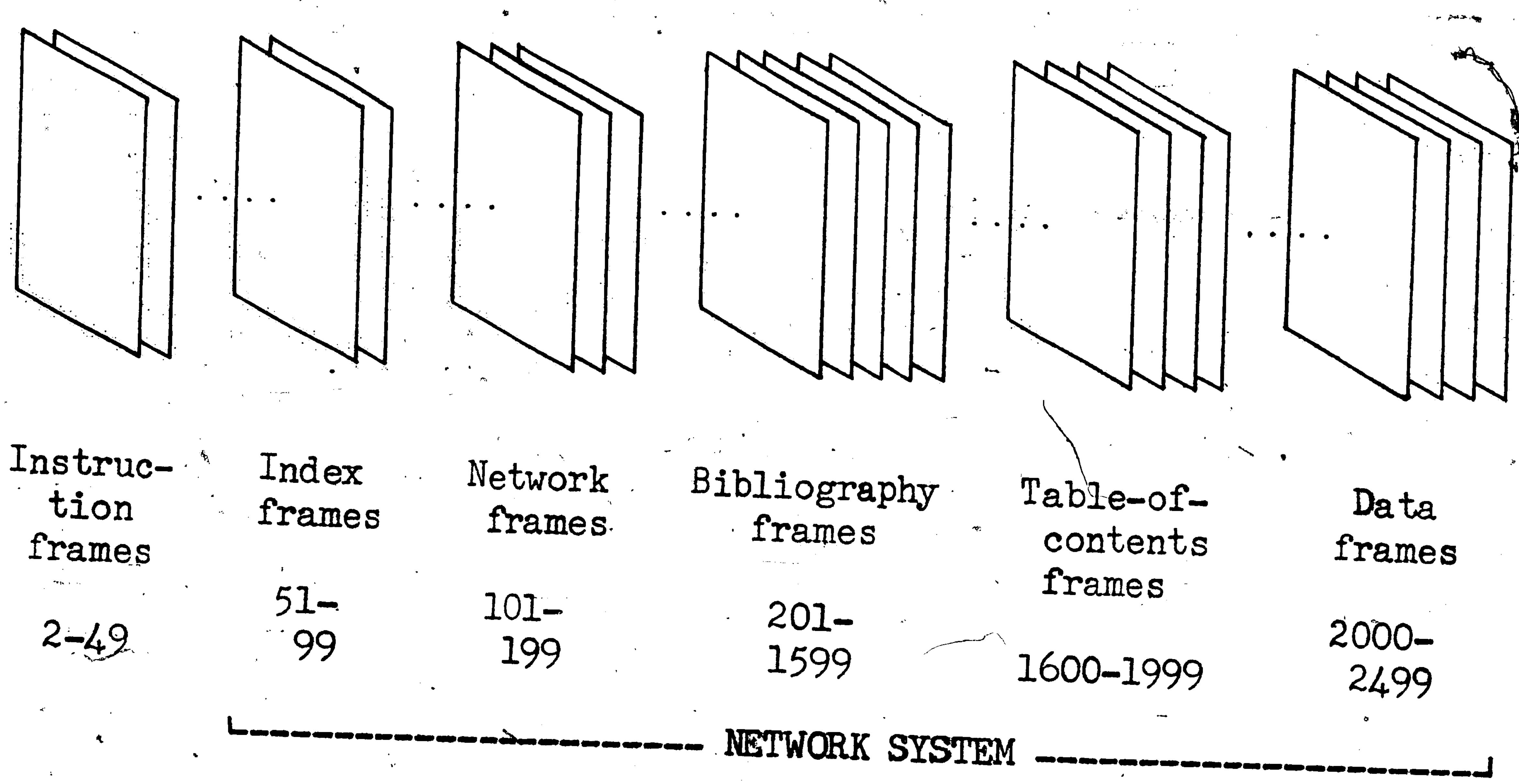
BRIEF DESCRIPTION OF THE SYSTEM

A general overview of the system is presented here.

Broadly speaking, there is, at present, provision for up to 2500 individual visual displays or "frames" which are intended to be randomly accessible. These frames are cross-referenced in such a way as to enable a student (a) to learn the use of engineering reference tools, and (b) to force him to specify his question. The means employed in achieving these goals are related to techniques of programmed instruction.[6] That is, unless the student learns both how to operate the mechanism (follow system directions) and how the material presented at each step should be used (gain facility with the subject matter), he can not progress to the goal (in most programmed instruction, completion of the sequence; here, achievement of satisfactory result in terms of finding which reference work contains the desired type of information). However, the nature of the material presented in this system is such that the usual tests with branching to remedial frames on errors are not possible. Presumably, a student reaching the wrong reference work will back-track or start anew.

More particularly, there are actually <u>two</u> systems, one within the other. The more inclusive of these, loosely spoken of as "the system" consists of all (programmed) instruction frames as well as the inner core or "network system." The network system is principally composed of a series of local "snapshots" of a subject-heading network adapted from the Library of Congress' subject-heading structure for Metallurgy and related topics.[7] Also included in the network system are (1) an alphabetical index to the network; (2) for each of a selected sample of headings, a frame containing representative relevant bibliographic entries; (3) for each of a selected sample of bibliographic entries, a reproduction (occupying several frames where necessary) of the table of contents; and (4) frames containing abstracts, tables, or even actual text, reproduced from some of the documents whose tables of contents are exhibited.

Figure 1. General Structure of the System.



(FRAMES 1, 50, 100, 200, and 2500 are alotted to system data.)

Regarding the subject-heading network frames, more should be said. These frames are graphic two-dimensional representations of the actual structure of the cross-references, displayed as network "maps" rather than lists, whereever practical (see Appendix, FRAMES 101 - 160). These shallow glimpses of the deeply structured network overlap conceptually, so that the effect is that of having photographed the network through a multiple-image "omnispection" lens and then separating, cross-referencing, and linearly arranging the various resultant "facet-views."[8]

On every frame, diverse paths lead back into the network; in fact, every node or vertex is ultimately linked with every other. It is hoped that the very appearance of these maps will prompt the user to browse from one to another, exploring relationships, getting ideas and seeing where they lead, and all the while learning -- almost accidentally -- how to specify and limit a research topic or retrieval request within the framework of a library system. The frames containing bibliographic information, tables of contents, and more specific content material are supposed to accelerate this learning process by reducing the time and effort consumed in checking user-selected headings against the actual content of available library holdings. It is further hoped that a student who has gone through this process will have acquired an awareness both of what specific kinds of reference tools are available in engineering and of the value of developing personal information-seeking strategies.

HISTORY OF THE PROJECT AND DETAILS OF THE SYSTEM

The choice of the LC-List as the basis for the subject-heading network resulted from the purely practical considerations that (1) it was available; (2) its use would permit comparisons between the developed system and existing library systems; and (3) the Lehigh University Library subject catalog, like most library subject catalogs, is based upon the LC-List.

The disadvantages of having made this choice were soon apparent, however. The principal and most lingeringly troublesome of these problems was the fact that the LC-List was not a single complete volume but rather a constantly growing and changing collection. The Sixth Edition (1957) was self-contained; but the cross-reference structure therein listed had been superseded, and the revisions had already been incorporated in the Lehigh Library subject catalog. In order to bring the cross-reference structure up to currency with the existing catalog, it was necessary to utilize the Supplements to the Sixth Edition which had been employed in revising the card catalog. However, these supplements contained only the changes, so that each supplement had to be compared individually to the Sixth Edition as well as to all interim supplements for each heading used. Furthermore, since new supplements arrived monthly, and the card catalog was therefore continually revised, the changes outran the investigator's ability to record them concurrently.

When the first six months of Supplements to the Seventh Edition were combined and arrived in one convenient unit, the revision process was halted. The network system was thus frozen at a currency status equivalent to the state of the LC-List in December, 1964.[9]

A second major problem, related to the one just mentioned (see below), was presented by the discovery of inconsistencies in the cross-reference structure of the LC-List, some of which were never corrected in the supplements. Now, while the LC-List is, admittedly, not intended to be an absolutely complete compilation of all terms used in every field,[10] inconsistencies in the cross-reference structure often exist in quite noticeable violation of the principles which have been set down for such references. For instance, that no cross-reference should exist between PLATINUM GROUP[11] and any of the six headings RUTHENIUM, RHODIUM, PALLADIUM, OSMIUM, IRIDIUM, and PLATINUM appeared to violate the principle that existing generically-related headings should be cross-referenced.[12]

One type of cross-reference omission was deliberate and regular, however. Because the LC-List is a linear, alphabetically-ordered sequence, there is no need to cross-reference consecutively-listed related headings. On the other hand, the proposed map system would require the missing references, so they had to be made explicit.

Finally, the LC-List is rather inconsistent with regard to "general references" -- cross-references to whole classes of headings (not all of which may exist), usually exemplified by one or two samples (see the illustration given below). Needless to say, such general references save a considerable amount of space, but they also severely limit the user's ability to browse in the system. Of course, the LC-List is intended to classify books, rather than knowledge;[13] but a library system fails of helpfulness if lack of subject knowledge is permitted to prevent a user from finding documents containing that knowledge. For instance, if one does not happen to know that niobium is a metal, one can never find out that NIOBIUM--METALLURGY is a heading from the general reference under METALLURGY which reads: "also subdivision Metallurgy under names of metals, e.g. Copper--Metallurgy; Gold--Metallurgy."[14] It was therefore deemed wise to render all general references specific. (Reference works were required for this process; ~~see~~ below.)[15]

Regarding the comment that the first major problem area (that of the lack of a single unified listing) and the second (that of inconsistency and incompleteness in the cross-reference structure) were related, the connection was simply that the former rendered the latter vastly more difficult and frustrating because every supplement had to be checked, not only for each heading, but also for each cross-reference. The misplacement or even omission of certain converse references was thus discovered.

Now, as has already been mentioned, the engineering dicipline chosen for the proposed system was Metallurgy. The reasons for this choice were also practical: (1) Metallurgy was considered to be a reasonably typical branch of engineering; (2) the Lehigh University Library has extensive coverage of material in this area; and (3) the investigator happened to be familiar with the concepts and terminology of Metallurgy.

Beyond the initial decisions (choice of basis and topic), then, the work proceeded in eight stages, as follows.

The first stage involved the transfer of the <u>LC-List</u> headings and cross-references to 5x8 cards. Each heading referred to from or referring to METALLURGY was written along with the cross-reference code[16] on a separate card upon which "Metallurgy" had already been recorded at the top. Thus the list:

METALLURGY.[17]
  <u>sa</u> Alloys.
    Aluminothermy.
    .
    .
    .
    Chemical engineering.
    .
    .
    .
    Powder metallurgy.
    .
    .
    .
  <u>also</u> <u>subdivision</u> Metallurgy <u>under</u> <u>names</u> <u>of</u> <u>metals</u>,
    e.g. Copper--Metallurgy; Gold--Metallurgy.
  xx Alloys.
    Chemical engineering.
    Ores.
    Oxygen--Industrial applications.

.
.
.
Note under Mineral industries.
--Apparatus and supplies.
.
.
.
--Research. See Metallurgical research.
--Standards.
.
.
.

became card entries[18]:

METALLURGY[16]
sa, xx Alloys

METALLURGY
sa,xx Chemical engineering

METALLURGY
sa Aluminothermy

METALLURGY
sa Copper--Metallurgy

METALLURGY
sa Gold--Metallurgy

METALLURGY
sa Powder metallurgy

METALLURGY
nu Mineral industries

METALLURGY
xx Ores

METALLURGY
xx Oxygen--Industrial applications

METALLURGY
--Research
s Metallurgical research

METALLURGY
--Apparatus and supplies
.
.
.
--Standards
.
.
.

This process was now repeated for each heading referred to from or referring to METALLURGY, then each heading referred to from or referring to each of those, and so on. For convenience, the following convention was adopted. METALLURGY was considered to be the single heading on the "A level" (or entry level), and each heading found under METALLURGY in the <u>LC-List</u> (with the exception of subdivisions indicated by "--") was considered to be on the "B level" (referred to from or referring to the entry heading). Therefore, to pick a representative few, the following are B-level headings: ALLOYS, COPPER--METALLURGY, MINERAL INDUSTRIES, OXYGEN--INDUSTRIAL APPLICATIONS, and METALLURGICAL RESEARCH (a special case), but not [METALLURGY]--STANDARDS.

When all of the B-level headings had been found, each in turn was used to locate C-level headings. The process was continued until headings which bore no obvious connection with the field of Metallurgy were reached. Such headings began to appear as early as on the C level and increased in proportion to the number of useful headings found on each level until the network of useful headings folded back upon itself with seven headings at the G level.[20] The resultant cross-reference structure turned out to be roughly kite-shaped, rapidly expanding at first but then slowly tapering toward the end (see Figure 2). The numbers from which these ratios were taken include respectively, the number of cards on each level added as a result of making general references specific, correcting inconsistencies, and supplying necessary cross-references lacking in the LC-List (as mentioned earlier).[21]

Figure 2. Approximate Level-to-level Ratios for Numbers of Useful Headings.

A : B	::	1 : 31
B : C	::	1 : 8
C : D	::	1 : 2
D : E	::	2 : 1
E : F	::	3 : 1
F : G	::	11 : 1

A special convention was used when rendering specific the general references involving subdivisions (such as "--Metallurgy"). If the subdivision was cross-referenced either in the LC-List or because of the investigator's own addition of references (as COPPER--METALLURGY refers to ZIERVOGEL PROCESS), then the heading-with-subdivision (e.g., COPPER--METALLURGY) was given a "see also" reference from the subdivision heading (METALLURGY); and this fact was allowed to determine the level of the heading-with-subdivision (here B, since METALLURGY is A-level). Two 5x8 cards were thus produced, one being the standard converse of the other, as in the following example.

METALLURGY
sa Copper--Metallurgy

COPPER--METALLURGY
  xx Metallurgy

However, if the subdivision was nowhere cross-referenced, the general reference was made specific by simply listing that heading, along with similar ones, on a single card, preceded by the special reference code "su," meaning "is found as a subdivision under." For instance, the general reference under METALLURGY resulted in a card that read:

METALLURGY
  su: Brass
      Bronze
      .
      .
      .
      Zirconium.

The corresponding card for one of these special references simply has the subdivision preceded by "--" listed along with other subdivisions for the main heading, and level is not affected by these references. For example, the single card:

BRASS
  --Analysis
  --Cold working
  --Corrosion
  --Metallography
  --Metallurgy
  --Welding

is one of many cards corresponding to the "su" card for METALLURGY, while itself corresponding to five other such "su" cards.

When the first stage of the project was completed, about 6500 5x8 cards had been prepared.

The second stage consisted of indexing this deck. Here, proceeding from level to level from A to G, each new heading, and the letter for its level, was recorded on a 3x5 card. These cards were then filed alphabetically. In fact, the indexing process had to be concurrent with stage one, for there were so many headings and cross-references that without the alphabetical index to heading levels there would probably have been much duplication and other errors. As it was, the data-base turned out to be quite "clean."

A count of index cards, matched with other information obtainable from the manner in which the 5x8 cards had been filed, now revealed that there were about 840 "productive" headings, i.e., headings the Library of Congress actually uses to describe documents, plus another 270 or so headings with "see" references to the productive headings, for a total of over 1100 headings associated with the field of Metallurgy. Approximately 3200 cross-references exist between these headings.

At this point it was apparent that the data-base could not be converted to maps in its entirety in a short span of time. Accordingly, the third stage of the project consisted of limiting the network system topic and selecting only the relevant headings. Since the actual design of maps would dictate certain choices here, in stage three only general decisions were made. Principally, the network system topic was determined to be the research area of corrosion and anti-corrosives and related fields within Metallurgy.

Stage four was immediately initiated, and mapping was begun. The map frames were designed as follows.

The first map (refer to Appendix, FRAME 101) to be constructed was centered on the entry heading, METALLURGY. Clustered about this focus, which appears entirely in upper case letters, are all headings of the original 840 which are referred to from or refer to METALLURGY. These headings appear in lower case and are underscored. Finally, wherever space permits, headings referred to from or referring to some of these secondary headings are indicated in lower case (not underscored). Cross-references are shown as arrows between the nodes (see the instructions on FRAME 6 for arrow-codes for the various cross-reference types). As things turned out, it took two frames (FRAMES 101, 102) to completely show the cross-reference structure for METALLURGY.

Next, selecting only those headings which were encompassed by the limited topic area (stage three), additional frames were produced. The first group of these exhausted the relevant B-level headings underscored on the METALLURGY frames. Eventually all seven levels were represented on the maps. On each frame one or more headings were designated as focal points and appeared in upper case. Headings linked directly to these foci by arrows were lower case underscored, and those headings further removed were non-underscored lower case.

Now on each map frame one or more headings are "complete" in the sense that all cross-references to and from such a heading will be shown on that frame, although some of these cross-references may be shown on other frames. As a general rule, a heading must be complete on a frame in order to be a focus for that frame; but headings other than those appearing in upper case may be complete on a frame. A frame on which the cross-reference structure is completely shown for a given heading is the "master-frame" for that heading. In the rare cases where a heading is complete on more than one frame, the master-frame is taken to be the one of these on which the largest number of headings referring to or referred to from the given heading are also complete. In the case of METALLURGY, which requires two frames for completeness, the master-frame is taken to be the one with the lower frame number (hence, FRAME 101); and the fact that more than one frame is required to exhibit the full structure is indicated by hyphens where the frame numbers are recorded (thus: "FRAME 101-" and "-FRAME 102").

A "master-frame index" could now be prepared for the finished frames. This index consists of 5x8 cards, one per frame, each of which shows the frame number, the focal headings for the frame (in upper case letters) and their levels (A, B, etc.), and, by level, each other heading appearing on the frame. Within each group, listing is alphabetical. Headings for which the frame is master are preceded by a check mark (✓). For instance, a copy of the card for FRAME

101 is presented in Figure 3.

Figure 3. Master-frame Index Card for FRAME 101.

✓ METALLURGY	A	FRAME 101[23]
		Complete A, B, C
Aluminothermy	B	Contains A, B, C
Cyanide process	B	Master ✓
✓ Hydrometallurgy	B	
Sintering	C	
Ziervogel process	C	
Thermit	C	

With the aid of these cards, the headings on the maps were cross-referenced by master-frame; and the master-frame numbers could also be recorded on the 265 3x5 cards selected from the original alphabetical index on the basis of the master-frame index. Now the original 5x8 data-cards were consulted, and 132 headings with "see" references to the 265 productive headings were discovered. The 3x5 index cards for these headings were also selected from the original alphabetical index; the "see" references were recorded on them; and the master-frames for the productive headings referred to were included in these "see" references. The 397 3x5 cards were then re-alphabetized, later to be used in preparing the frames containing the alphabetical index to the 19 map frames which had been produced.[24]

At this point the fifth stage of the project was begun. For each frame, one or two headings for which that frame is the master-frame were chosen. An attempt was made to select headings which were "characteristic" of the facet of Metallurgy depicted on the frame. Then an annotated bibliography[25] was consulted, and a list of titles representing what appeared to be the most comprehensive and authoritative works relevant to each of the chosen headings was compiled.

Stage six involved obtaining as many as possible of the documents whose titles were on this list.

Stage seven, concurrent with stage six, was the reproduction of the tables of contents (and sometimes sample data tables) of these documents. (Each $8\frac{1}{2}$x11 page thus produced would eventually become a separate frame.)

When all copies had been made, the eighth and final stage of the project was begun. At this time a working table for calculating bibliography and table-of-contents frame numbers was set up. Based upon (1) estimates of the amount of space that could be expected to be required were all of Metallurgy to be included in the system and (2) the document lists for the chosen representative headings (stage five), frame numbers were allocated from 201 through 2499 as shown in Figure 1 (above).

If the amount of space allocated to bibliographic listings (almost 1400 frames) seems disproportionately large, recall that there are about 840 productive headings in the full network and that there may be bibliographic entries for which tables of contents are not available for copying. Of course, if the estimates prove to be too low, a larger number of frames may be used; the random accessibility of the frames precludes any need for renumbering them.

Specific frame numbers for the bibliography, table-of-contents, and data-table/text frames were calculated and assigned by means of the working table. Needless to say, these numbers could have been assigned in simple serial order starting at 201; but, since the system is experimental, it was thought wiser to try to allow for gradual organized fill-in of pre-planned gaps so that someone studying the system itself could isolate homogeneous blocks of frames (all having titles or all having tables of contents, for example).

IMPLEMENTATION OF THE SYSTEM

The most important aspect of the system herein discussed is the allowance made for browsing, not only in the subject-heading network itself, but also in the tables of contents of documents described by the subject headings.[26] Consequently, the hardware used to implement the system must be designed for random access of stored material, with a variety of formats.

A second major consideration is that the user be able to obtain copies of any frames which are of interest to him, whether they be bibliographic lists, tables of contents, or even network frames. Accordingly, in order that the user not be inconvenienced, the hardware used to implement the system must be capable of producing these copies quickly while the user is viewing the frames in question. The user should not have to move to another location to obtain copies.

Furthermore, it is desirable that the user be able to operate the equipment with a minimum of instruction; preferably only that which can be displayed on a single poster nearby. In particular, he should not have to perform more than one filing operation, i.e., to insert more than one cartridge and later return it to its bin. It would be even better if he need not perform any. Since it is expected that the system will involve either microfilm or some type of microfiche, this requirement means that at most the user may have to load one closed magazine into the locator-viewer and later replace it in its designated storage pocket. The controls should be as few as possible; and those used for the selection of frames should be either like an ordinary telephone dial or like a calculator keyboard, rather than rotary switches or levers. It should not be necessary to hold down a button or lever in order either to retain an image on the screen or to ensure that a copy will be made. In addition, there should be a separate control for advancing or back-tracking one frame at a time for maximum ease of browsing serially, scanning index frames, and/or reading a table of contents that occupies more than one frame.

Of course, the rationale behind the emphasis on the above considerations is that the hardware itself must not limit the system's ability to serve the student, nor should it confuse or bore him.

Besides the user-oriented criteria, though, one system criterion must be met. Assuming that the network system may eventually be expanded to cover more (or all) of the field of Metallurgy, or even of Engineering in general, there must be provision for updating the frames. In fact, the mere existence of newer reference works in the area now mapped will sooner or later result in a need for updating the frames in the bibliographic list section.

Various hardware systems have been investigated for compatibility with the above criteria. One of the more interesting items was the "Videosonic" System,[27] which provides pre-recorded audio accompaniment to the visual displays (slides). The addition of sound for commentary and instruction has tremendous potential value in conjunction with randomly accessed frames, and the Videosonic system is not at all expensive; but unfortunately there is provision for only 36 slides at one time,[28] and the user cannot be expected to reload the machine.

For the present system, or even its proposed expansion to include all of Metallurgy, the optimum choice of hardware appears to be Recordak Corporation's "Lodestar Reader-Printer," Model PES, with Recordak "Image Control Keyboard," Model IC-2. The Reader-Printer is user-loaded with a magazine containing 100 feet of 16mm microfilm which contains about 2500 frames, and the Keyboard affords five-second location of any frame. There is provision for moving the film one frame at a time; and, if desired, a copy of a frame can be produced within 30 seconds of the time the frame has been located. After 17 seconds the film may be moved to a new frame without affecting the copy being made.[29] This hardware system is both inexpensive and proven. Regarding updating, a new film must be made, but frames of the old film could be photoreproduced in this process if they are unaffected by the update. As presently designed, the proposed system permits taking maximal advantage of this possibility.

However, for a much larger system -- for instance, if one envisions replacing the entire subject catalog with such a system -- hardware such as that being developed by Houston Fearless Corporation would have to be employed. Their "... CARD (Compact Automatic Retrieval Display) system is a desk-top, self-contained microfiche file-reader." It provides pushbutton-controlled "... 4-second access to any microfilmed page in a total of 70,000 pages contained in the internal file" on 750 edge-notched filmcards. A printer may be incorporated into the system, and updating of the file is quite easy. The CARD system may even be computer-manipulated.[30] Thus, ~~the computer~~ could generate displays which would force the user to specify his question -- for instance, by his answering "yes" or "no" to predesigned cue questions -- and then present the requisite frame.

GENERAL REMARKS

In view of the amount of time the investigator spent working with the LC-List, some further commentary on it seems appropriate. Also, some remarks about the compatibility of the proposed system with various established structured term-lists, such as engineering thesauri, are in order.

It has already been mentioned that the presence of general references severely limits the user's ability to browse in the LC-List. This difficulty is inevitably carried over into any subject catalog based upon the LC-List. But in the card file browsability is also hampered by the sheer physical arrangement of entries on separate cards whose faces can be scanned only one at a time, as well as by the presence of an indefinite number of bibliographic cards per heading. Hence, it would at first seem as though the user interested in following cross-references would be better off if he were to check his headings in the LC-List instead of the card file and afterwards use the subject catalog to find titles only. Yet it must be remembered that the LC-List is not a single self-contained list; the many supplements are filled with additions, changes, and deletions. Some parts of the cross-reference structure have been changed many times in the supplements, and a few changes have even geen cancelled and then later reinstated. Thus it seems that the more cumbersome -- but unified -- card file is the user's better choice. However, if the MARC Pilot Project of the Library of Congress[31] results in a computerized list of subject headings appearing _in toto_ at regular intervals, the previously mentioned alternative would be preferred.

Now in defense of general references it has been stated that the _LC-List_ is a classification of (existing) books rather than (potentially unpublished) knowledge, while in further criticism of such references it has been mentioned that the user's ability to find existing books may be hampered by his own lack of knowledge if cross-references are not explicit. It would be somewhat unfair to leave the impression that this charge, which is sharper than the remark about poor browsability, is entirely unanswerable. Indeed, special libraries must and do add headings to the basic list the Library of Congress provides; and, in fact, the Library of Congress supplies guidelines for doing so.[32] But general libraries, including large ones, may not even use all of the headings in the _LC-List_ on the theory that only headings actually used to describe present holdings (plus "see" references to these headings) are necessary. Of course, there can be no doubt that the reduced structure is easier to update than is the full one. Yet, if two actually used headings are, in the _LC-List_, indirectly linked _via_ a third heading which the library does _not_ use, a cross-reference chain which might be conceptually important to some user of the system has been broken. The point is that, while this last problem may not seem serious enough to warrant increasing updating costs, when it is combined with the problem of the general reference the result _is_ serious.

The investigator conjectures that, because of the above omissions and because of the unwieldiness of cards in general, virtually none but the most determined users ever employ the "see also" reference in the typical subject catalog. It is therefore suggested that, if this situation is to be improved, the Library of Congress must abolish the general reference and libraries must follow suit by rendering explicit the general references that exist among the headings they actually use. Indeed, without this necessary addition, the effort already spent on setting up the cross-references is in practice largely unjustified.

The proposed system, which avoids all of the aforementioned barriers to user convenience in ways which have already been discussed, is consequently very much akin to the type of system which might serve a highly specialized library. In other words, the system described in this paper is much more compatible with _knowledge_-classificatory systems than the book classifications like the _LC-List_. Its closest relative is the _Euratom-Thesaurus_, which also employs the chart form of display.[33] It is also compatible with the _Thesaurus of ASTIA Descriptors_,[34] the Engineers Joint Council _Thesaurus of Engineering Terms_,[35] and the _ASM-SLA Metallurgical Literature Classification_[36] to the extent that these contain cross-references which are mappable. None of these four knowledge classifications contain general references, and all are self-contained in each edition.

SUGGESTIONS FOR FURTHER RESEARCH AND DEVELOPMENT

Since the proposed system would be highly compatible with the subject catalog of any special library devoted to the field of Metallurgy, it would be interesting to install an implemented version of the proposed system in such a library and to compare the relative efficiencies of the two as access mechanisms. It would certainly be interesting to test an implemented version of the system for effectiveness in teaching student engineers the importance and method of active and systematic information-seeking strategies. If the Houston Fearless CARD system is used for implementing the system, it would be interesting to examine any particular updating problems which might arise as the network system expands toward all of engineering. Probably a method of computer-assisted, or even fully computer-controlled, map construction would have to be developed.

APPENDIX

POSTED DIRECTIONS: NECESSARY INCLUSIONS

The posted directions for the implemented system must contain, in addition to commentary to the effect that there is provision for random frame access, direction to the user to proceed to FRAME 2. This instruction is necessary in order that the user avoid the system data on FRAME 1.

Once the user reaches FRAME 2, the system teaches its own use.

THE SYSTEM

Note: Numbers appearing at the very bottom of the frames which follow are page numbers of this paper and would not appear on actual implemented system frames.

This system was initially designed by Michael B. Leibowitz under the guidance of Professor Robert S. Taylor, Director, Center for the Information Sciences, Lehigh University Library.

YOU SHOULD NOT BE READING THIS FRAME.

THE DIRECTIONS POSTER EXPLICITLY REFERS YOU TO FRAME 2.

You are about to employ a system which is somewhat analogous to the SUBJECT CARD CATALOG except that:

(1) You will not have to search serially through unwanted cards,

(2) you will not have to move from one location to another in order to trace cross-references,

(3) you will not have to go to the "stacks" to examine tables of contents of documents whose titles interest you,

and

(4) you will be able to obtain copies of any frames in this system which are useful to you, merely by following the directions on FRAME 4.

PLEASE SELECT <u>FRAME 4</u>.

Remember that this is a random access system. You do not progress serially unless you are either browsing or reading through several serially ordered frames of a set, such as a long table of contents.

Therefore, YOU SHOULD NOT BE READING THIS FRAME. PLEASE RETURN TO FRAME 2 AND REREAD THE LAST INSTRUCTION.

[Instructions here will depend upon the specific hardware used for implementing the system. Any directions given, however, will end as follows.]

PLEASE SELECT <u>FRAME</u> <u>6</u>.

Remember that this is a random access system. You do not progress serially unless you are either browsing or reading through several serially ordered frames of a set, such as a long table of contents.

Therefore, YOU SHOULD NOT BE READING THIS FRAME. PLEASE RETURN TO FRAME 4 AND REREAD THE LAST INSTRUCTION.

HOW TO USE THIS SYSTEM

A. 1. Scan the ALPHABETICAL INDEX until you find a heading which interests you.

2. To reach the frame on which the cross-reference structure for this heading is most complete, select the frame number given. (If no frame number is given, the master-frame for the heading has not yet been constructed.)

B. 1. Locate your heading on the NETWORK FRAME you reach.

2. Headings printed in UPPER CASE letters are focal points for the conceptual area covered by the frame.
All headings directly cross-referenced from or to focal headings are underlined.
All headings only indirectly linked with focal headings are printed plain.

3. ARROWS indicate that headings are conceptually related:

More general heading ——————→ More specific heading

Co-ordinate heading ←————→ Co-ordinate heading

Heading - - - - → Subdivision (used in conjunction with symbol "--" before name of subdivision)

4. As you browse among the headings shown on the frame, you will notice that some are accompanied by numbers:
101 - 199: NETWORK FRAME number. Like the numbers given in the Alphabetical Index, this number represents the number of the frame on which the cross-reference structure for the heading in question is most complete.
201 - 1599: BIBLIOGRAPHY FRAME number. The presence of such a number is an indication that the frame being viewed contains the most complete cross-reference diagram (i.e., is the master-frame) for the given heading.
NO NUMBER: The frame being viewed is the master-frame for the heading, but as yet no bibliography frame for this heading has been made. Bibliography frames have been produced only for a few representative headings on each frame. (If you wish to use a heading not accompanied by a number, try to find it in the regular library subject catalog; but be forewarned that it may not be there.)

C. A number given after an entry on a BIBLIOGRAPHY FRAME refers to the number of the frame containing the document's Table of Contents.

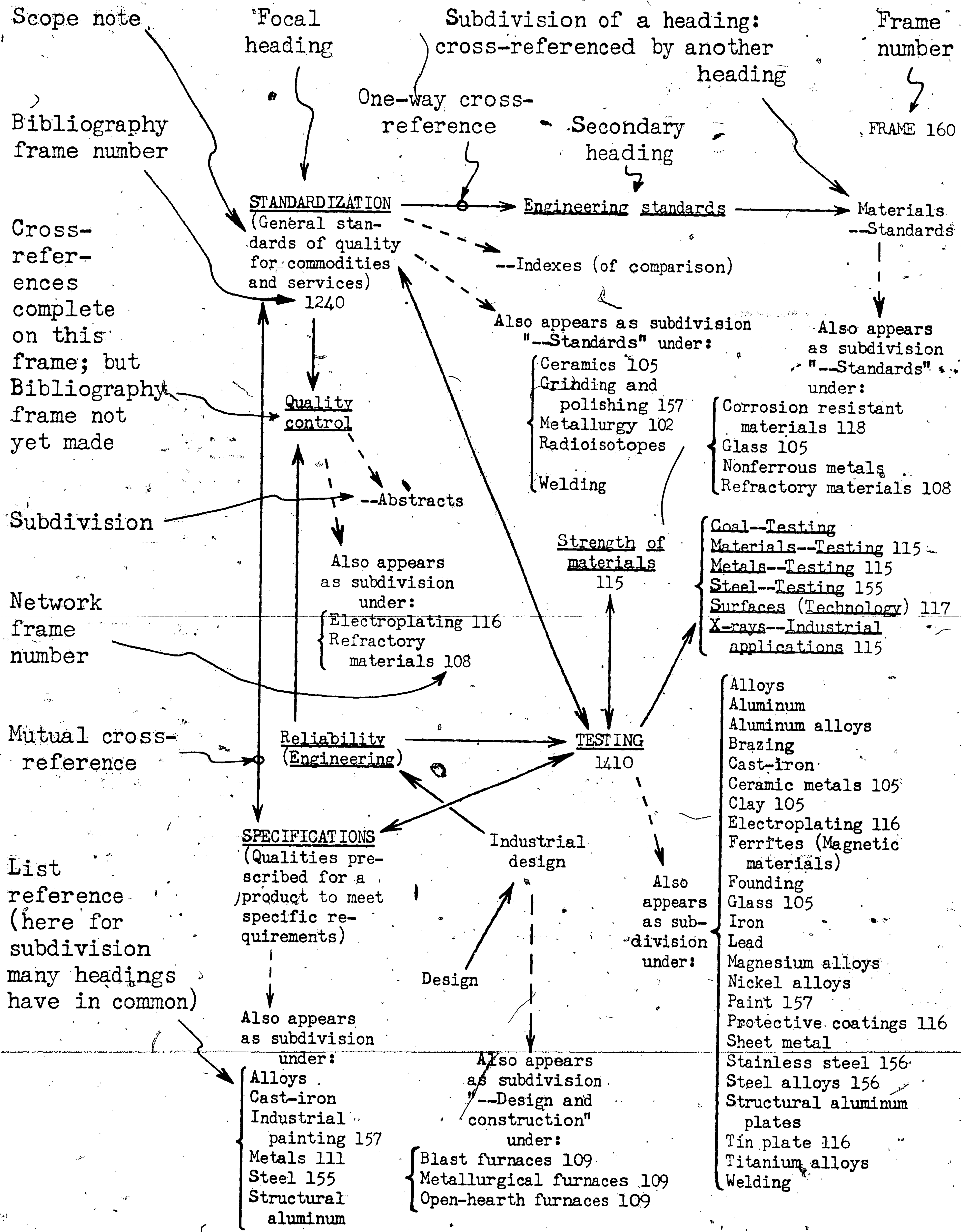
D. Frame numbers given after entries on a TABLE-OF-CONTENTS FRAME refer to the locations of abstracts, significant data-tables, portions of text, etc.

E. A HYPHEN (-) after a frame number means: "continued on next frame." A hyphen before a frame number means: "continued from previous frame." Thus: "FRAME 101-"; "-FRAME 102"

EXAMPLES FOR STEP B: SEE FRAME 7.

IT IS ADVISED THAT YOU MAKE A COPY OF BOTH FRAME 6 AND FRAME 7 FOR REFERENCE.

SAMPLE NETWORK FRAME



THE ALPHABETICAL INDEX FOR METALLURGY BEGINS ON FRAME 51.

FRAMES 51 - 99:

ALPHABETICAL INDEX SEQUENCE

for FRAMES 101 - 199

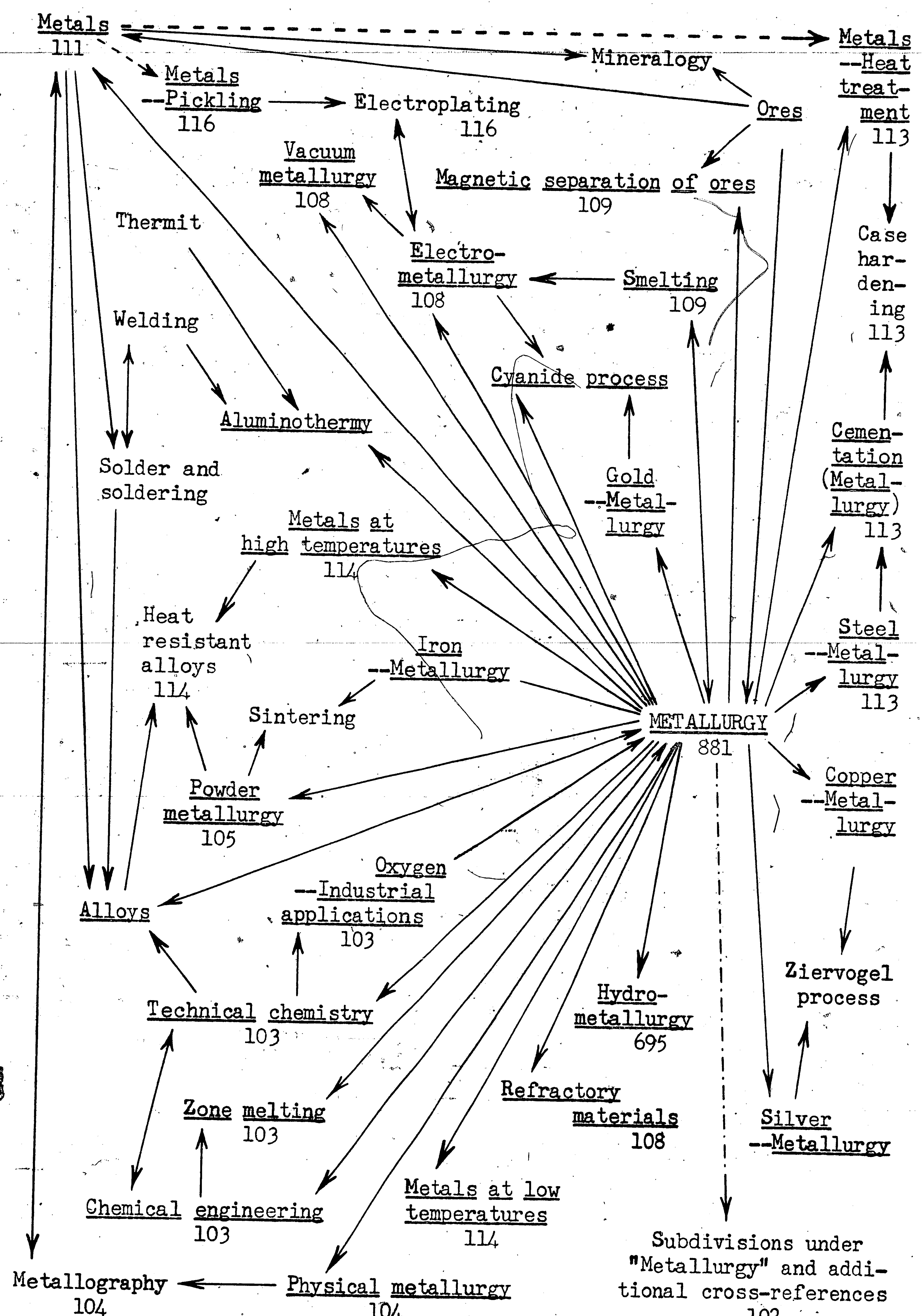
Indexing Principle: All references, even SEE references, go directly to the master-frames for the headings involved. In no case is a cross-reference to be made in the Index itself.

ALPHABETICAL INDEX

FRAMES 101 - 199:

MAP SEQUENCE

for METALLURGY


Metals
111
Metals
--Pickling
116
Electroplating
116
Mineralogy
Ores
Metals
--Heat
treat-
ment
113
Vacuum
metallurgy
108
Magnetic separation of ores
109
Thermit
Electro-
metallurgy
108
Smelting
109
Case
har-
den-
ing
113
Welding
Cyanide process
Aluminothermy
Cemen-
tation
(Metal-
lurgy)
113
Solder and
soldering
Gold
--Metal-
lurgy
Metals at
high temperatures
114
Heat
resistant
alloys
114
Iron
--Metallurgy
Steel
--Metal-
lurgy
113
Sintering
METALLURGY
881
Powder
metallurgy
105
Copper
--Metal-
lurgy
Oxygen
--Industrial
applications
103
Alloys
Ziervogel
process
Technical chemistry
103
Hydro-
metallurgy
695
Refractory
materials
108
Zone melting
103
Silver
--Metallurgy
Chemical engineering
103
Metals at low
temperatures
114
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"Metallurgy" and addi-
tional cross-references
102
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104
Physical metallurgy
104

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(Continued from 101)
881

Also appears as subdivision under:

- Brass
- Bronze
- Cadmium
- Carbonate ores
- Cast-iron
- Lead
- Light metals
- Magnesium
- Manganese
- Mercury
- Molybdenum
- Nickel
- Niobium
- Nonferrous metals
- Oxide ores
- Phosphate ores
- Platinum group
- Sulfate ores
- Sulfide ores
- Tantalum
- Thorium
- Tin
- Titanium
- Tungsten
- Uranium
- Zinc
- Zirconium

--Apparatus and supplies
--Catalogs and collections
--Graphic methods
--Information services 885
--Laboratory manuals
--Standards 887
--Tables, calculations, etc.
--Terminology

Metallurgical research

Coal research

Engineering research

Industrial research

Welding research

Chemical engineering research

Research

Chemical engineering 103

Chemical research

Also subdivision under: Ceramics 105

Technical chemistry 103

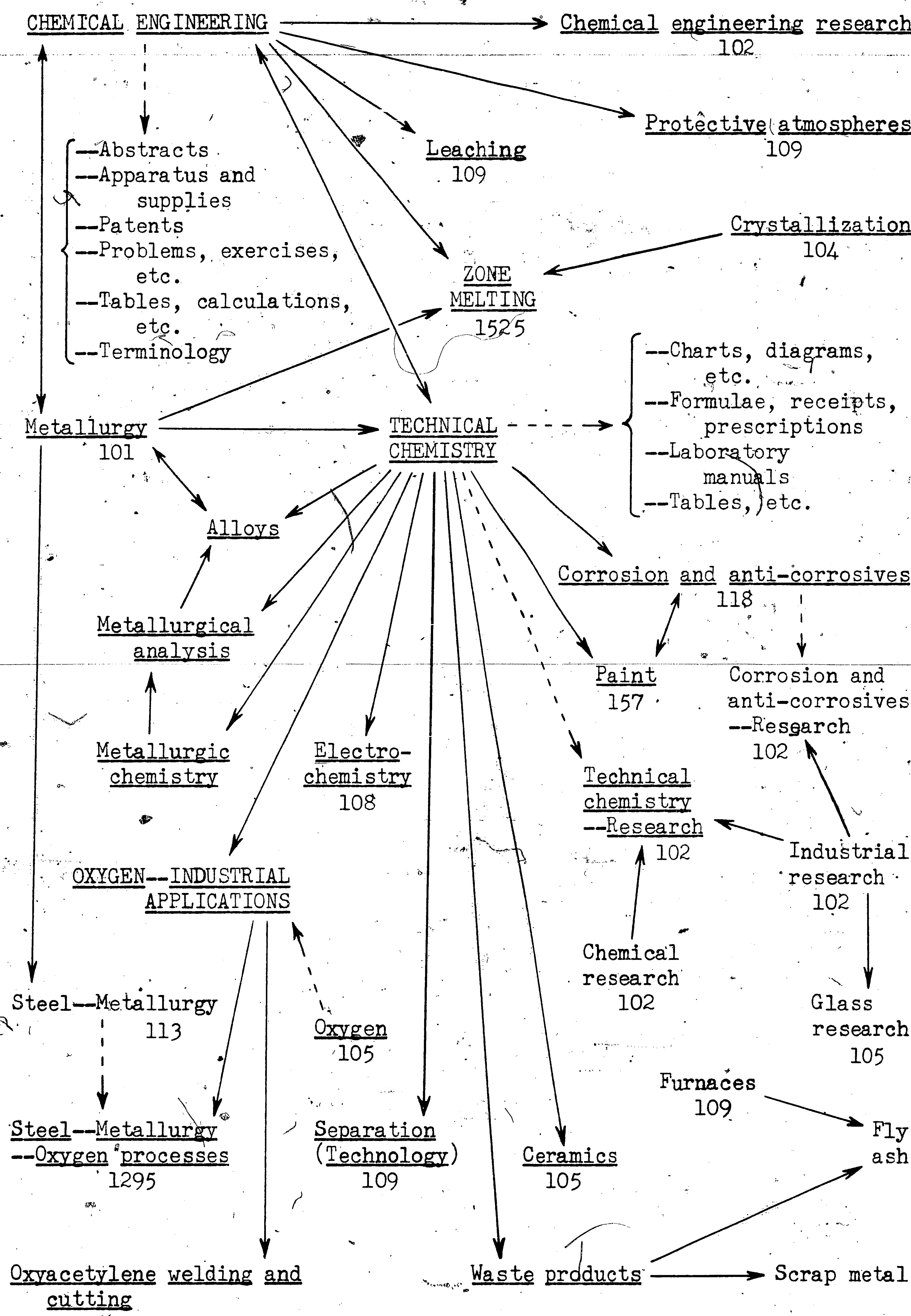
Technical chemistry--Research

Paint 157

Glass--Research 105

Corrosion and anti-corrosives 118

Corrosion and anti-corrosives--Research


CHEMICAL ENGINEERING
Chemical engineering research
102
Protective atmospheres
109
Leaching
109
--Abstracts
--Apparatus and supplies
--Patents
--Problems, exercises, etc.
--Tables, calculations, etc.
--Terminology
Crystallization
104
ZONE MELTING
1525
--Charts, diagrams, etc.
--Formulae, receipts, prescriptions
--Laboratory manuals
--Tables, etc.
Metallurgy
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TECHNICAL CHEMISTRY
Alloys
Corrosion and anti-corrosives
118
Metallurgical analysis
Paint
157
Corrosion and anti-corrosives --Research
102
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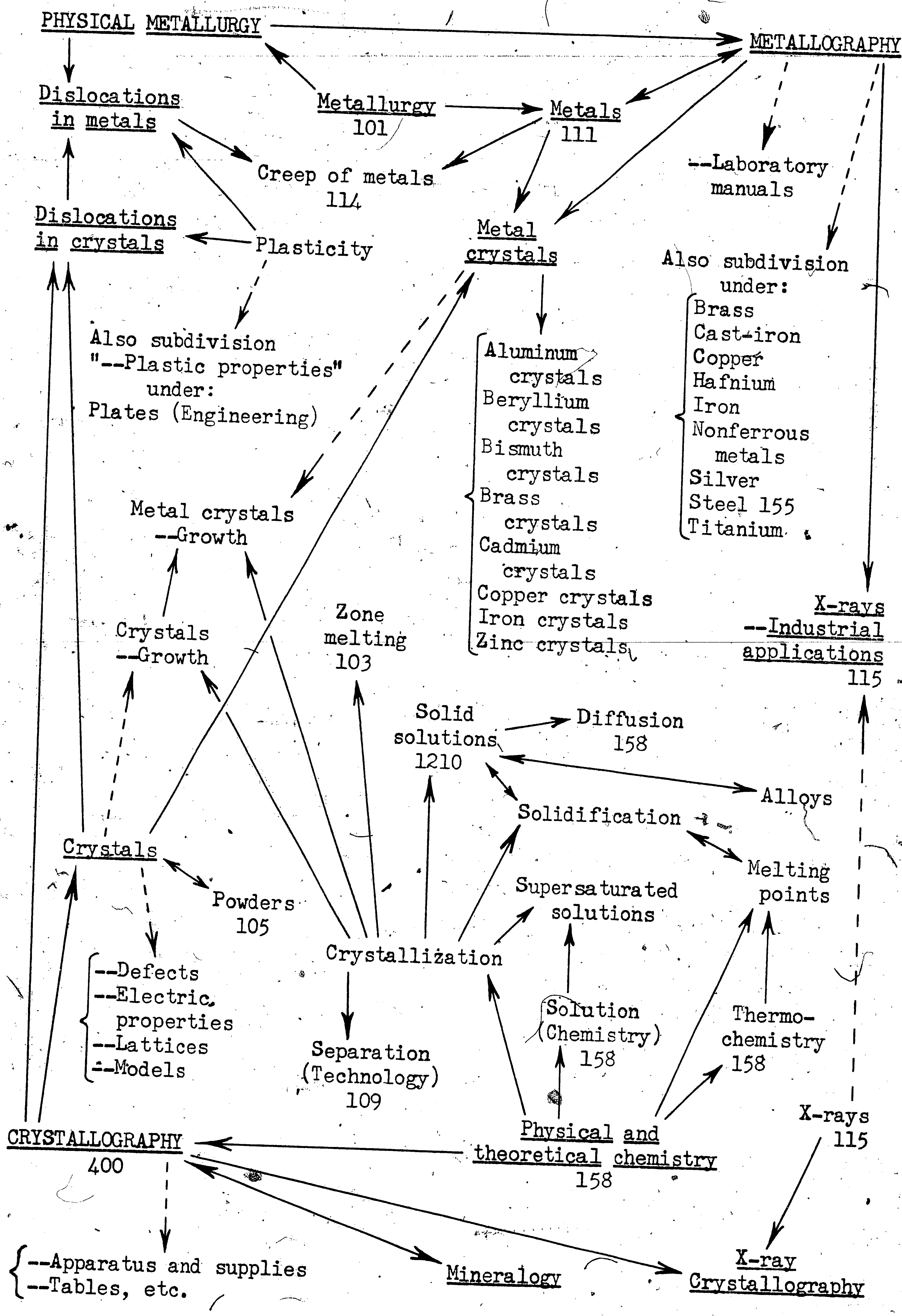
Electro-chemistry
108
Technical chemistry --Research
102
Industrial research
102
OXYGEN--INDUSTRIAL APPLICATIONS
Chemical research
102
Glass research
105
Steel--Metallurgy
113
Oxygen
105
Furnaces
109
Steel--Metallurgy --Oxygen processes
1295
Separation (Technology)
109
Ceramics
105
Fly ash
Oxyacetylene welding and cutting
Waste products
Scrap metal


PHYSICAL METALLURGY
METALLOGRAPHY
Dislocations in metals
Metallurgy 101
Metals 111
--Laboratory manuals
Creep of metals 114
Dislocations in crystals
Plasticity
Metal crystals
Also subdivision under:
Brass
Cast-iron
Copper
Hafnium
Iron
Nonferrous metals
Silver
Steel 155
Titanium
Also subdivision "--Plastic properties" under:
Plates (Engineering)
Aluminum crystals
Beryllium crystals
Bismuth crystals
Brass crystals
Cadmium crystals
Copper crystals
Iron crystals
Zinc crystals
Metal crystals --Growth
Crystals --Growth
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X-rays --Industrial applications 115
Solid solutions 1210
Diffusion 158
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Crystals
Powders 105
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Melting points
Crystallization
--Defects
--Electric properties
--Lattices
--Models
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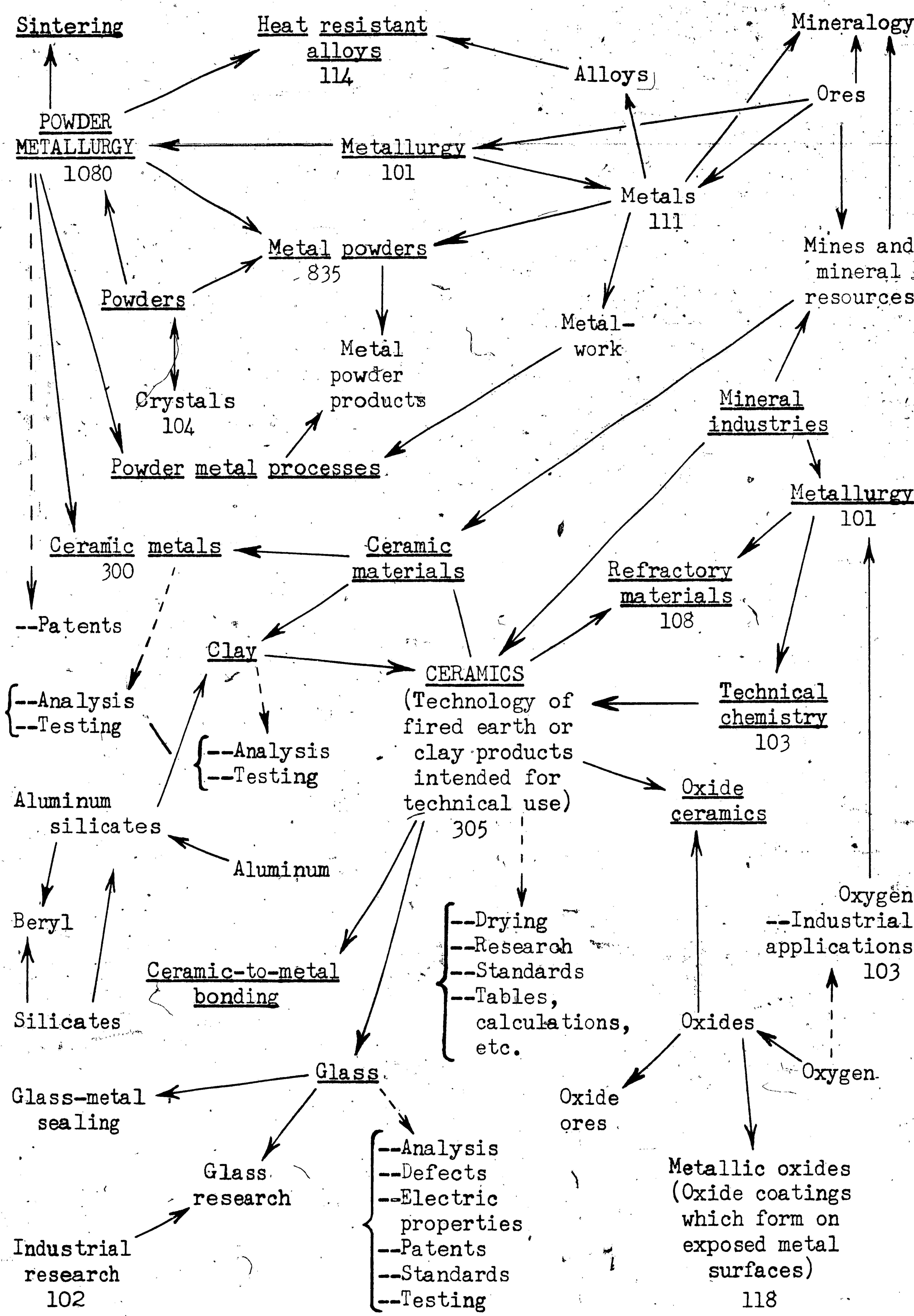
Solution (Chemistry) 158
Thermochemistry 158
X-rays 115
CRYSTALLOGRAPHY 400
Physical and theoretical chemistry 158
--Apparatus and supplies
--Tables, etc.
Mineralogy
X-ray Crystallography


Sintering
Heat resistant alloys
114
Alloys
Mineralogy
Ores
POWDER METALLURGY
1080
Metallurgy
101
Metals
111
Metal powders
835
Powders
Mines and mineral resources
Metal-work
Metal powder products
Crystals
104
Mineral industries
Powder metal processes
Metallurgy
101
Ceramic metals
300
Ceramic materials
Refractory materials
108
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Clay
CERAMICS
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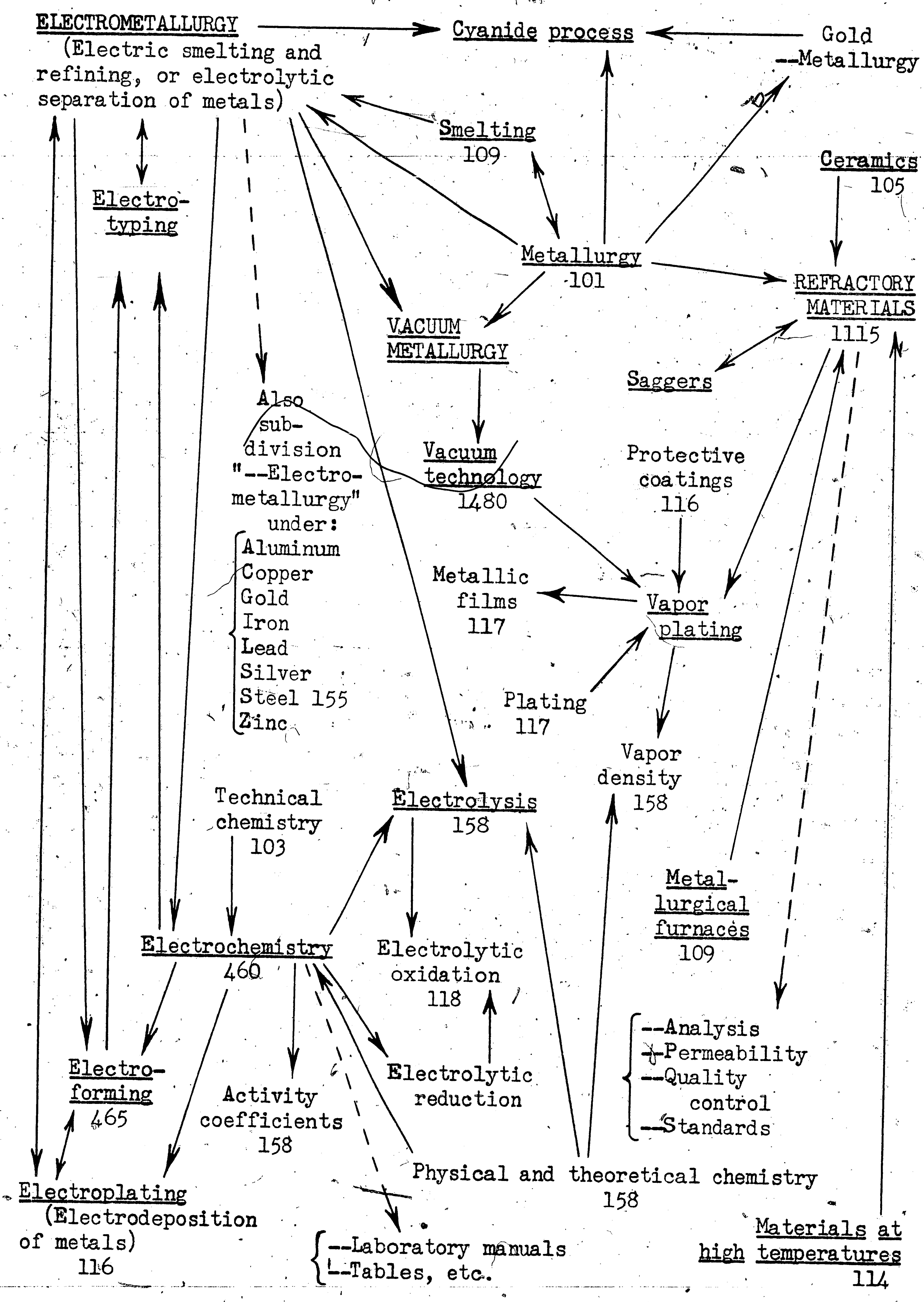
305
Technical chemistry
103
--Analysis
--Testing
--Analysis
--Testing
Oxide ceramics
Aluminum silicates
Aluminum
Oxygen
--Industrial applications
103
Beryl
--Drying
--Research
--Standards
--Tables, calculations, etc.
Ceramic-to-metal bonding
Silicates
Oxides
Oxygen
Glass
Glass-metal sealing
Oxide ores
--Analysis
--Defects
--Electric properties
--Patents
--Standards
--Testing
Glass research
Metallic oxides
(Oxide coatings which form on exposed metal surfaces)
118
Industrial research
102


ELECTROMETALLURGY
(Electric smelting and refining, or electrolytic separation of metals)
Cyanide process
Gold
--Metallurgy
Smelting
109
Ceramics
105
Electro-
typing
Metallurgy
101
REFRACTORY
MATERIALS
1115
VACUUM
METALLURGY
Saggers
Also
sub-
division
"--Electro-
metallurgy"
under:
Aluminum
Copper
Gold
Iron
Lead
Silver
Steel 155
Zinc
Vacuum
technology
1480
Protective
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116
Metallic
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117
Vapor
plating
Plating
117
Vapor
density
158
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chemistry
103
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158
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lurgical
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118
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--Permeability
--Quality
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--Standards
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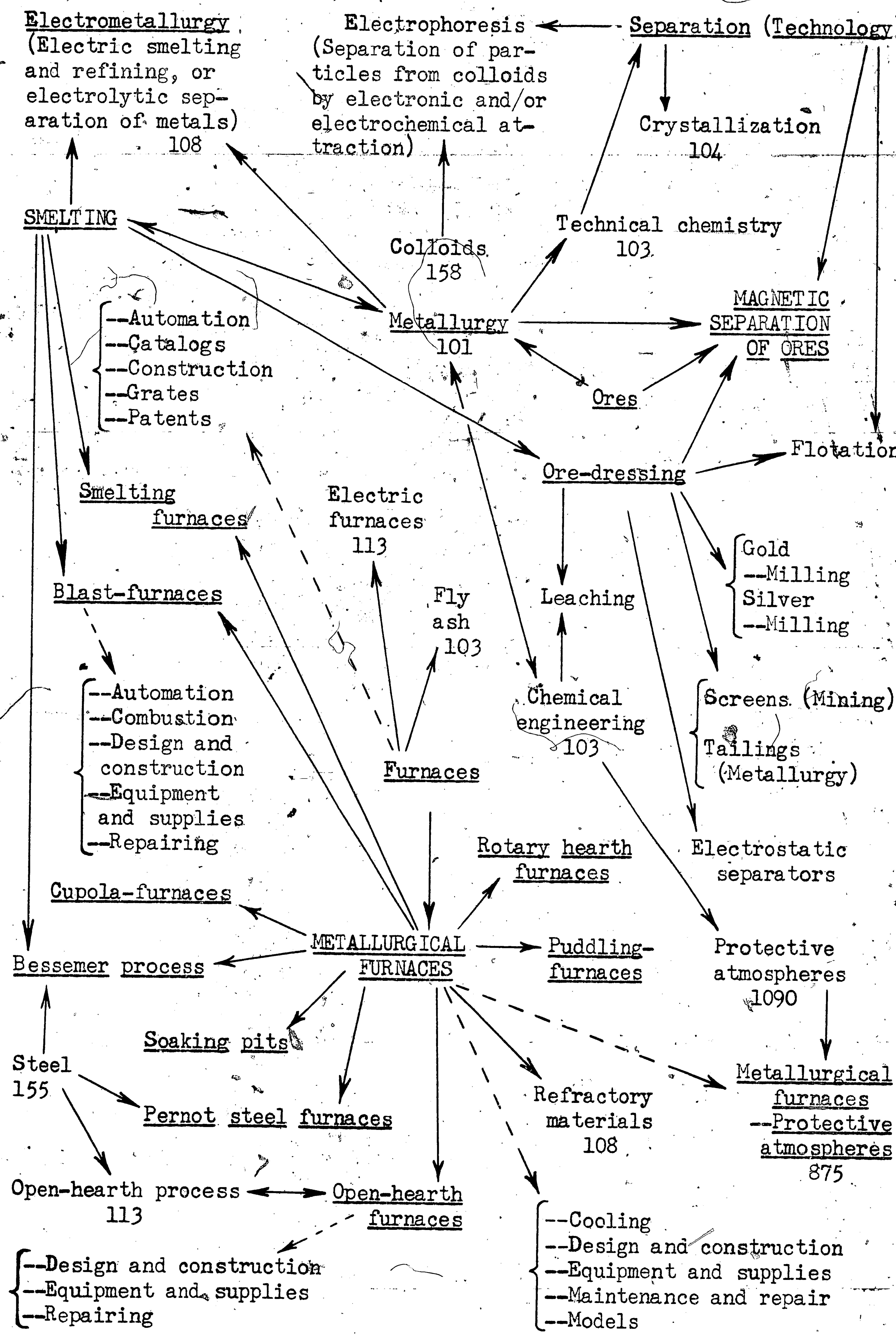
465
Activity
coefficients
158
Electrolytic
reduction
Physical and theoretical chemistry
158
Electroplating
(Electrodeposition
of metals)
116
--Laboratory manuals
--Tables, etc.
Materials at
high temperatures
114


Electrometallurgy
(Electric smelting and refining, or electrolytic separation of metals)
108
Electrophoresis
(Separation of particles from colloids by electronic and/or electrochemical attraction)
Separation (Technology)
Crystallization
104
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Colloids
158
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103
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--Catalogs
--Construction
--Grates
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101
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Electric furnaces
113
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--Milling
Blast-furnaces
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103
Leaching
--Automation
--Combustion
--Design and construction
--Equipment and supplies
--Repairing
Chemical engineering
103
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Tailings (Metallurgy)
Furnaces
Rotary hearth furnaces
Electrostatic separators
Cupola-furnaces
METALLURGICAL FURNACES
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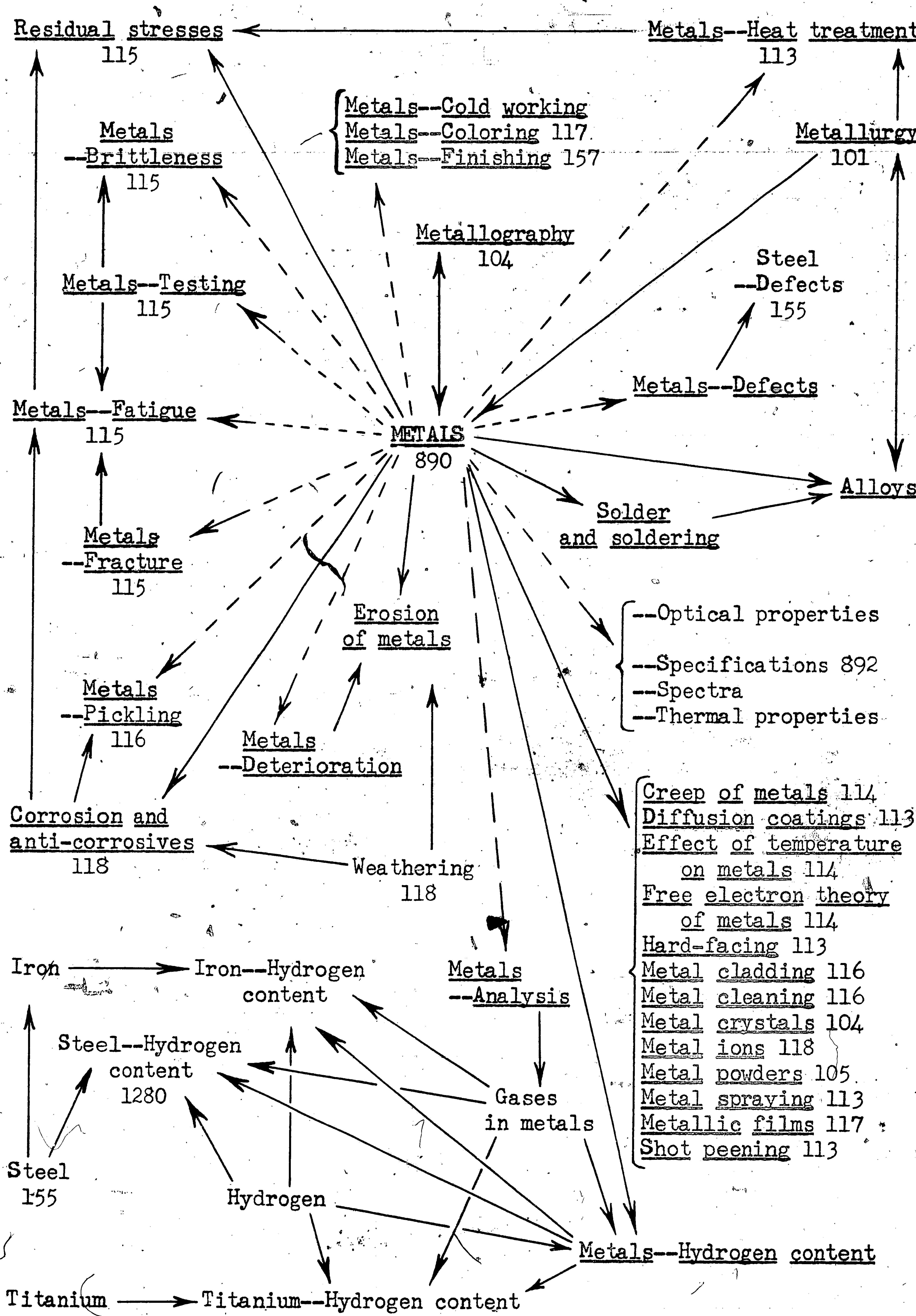
1090
Bessemer process
Soaking pits
Steel
155
Pernot steel furnaces
Refractory materials
108
Metallurgical furnaces
--Protective atmospheres
875
Open-hearth process
113
Open-hearth furnaces
--Design and construction
--Equipment and supplies
--Repairing
--Cooling
--Design and construction
--Equipment and supplies
--Maintenance and repair
--Models


Residual stresses 115
Metals--Heat treatment 113
Metals--Cold working
Metals--Coloring 117
Metals--Finishing 157
Metals --Brittleness 115
Metallurgy 101
Metallography 104
Metals--Testing 115
Steel --Defects 155
Metals--Defects
Metals--Fatigue 115
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Metals --Fracture 115
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--Optical properties
--Specifications 892
--Spectra
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Metals --Pickling 116
Metals --Deterioration
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Free electron theory of metals 114
Hard-facing 113
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Metal cleaning 116
Metal crystals 104
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Metals --Analysis
Steel--Hydrogen content 1280
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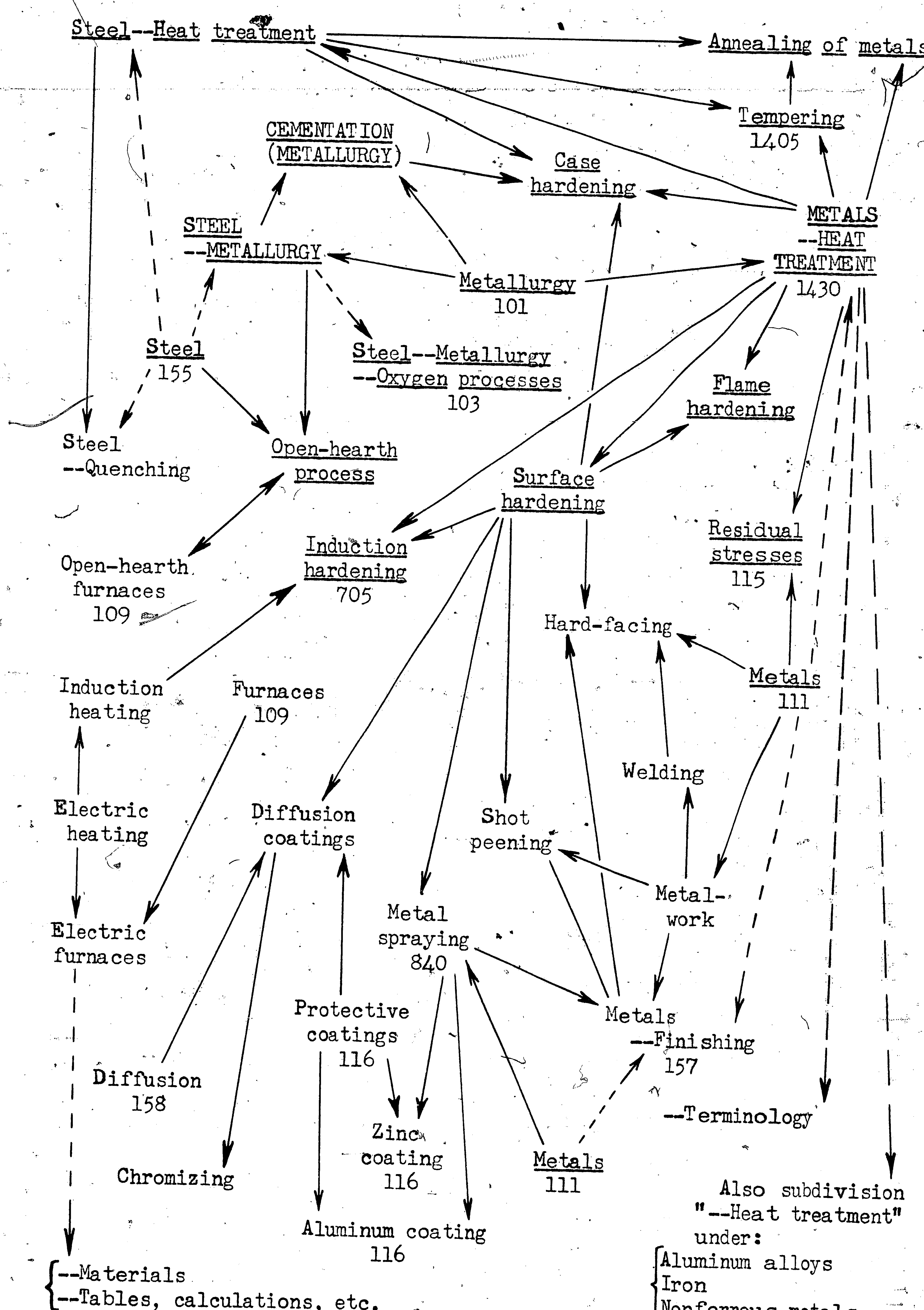
Metals--Hydrogen content
Titanium
Titanium--Hydrogen content


Steel--Heat treatment
Annealing of metals
Tempering
1405
CEMENTATION
(METALLURGY)
Case
hardening
METALS
--HEAT
TREATMENT
1430
STEEL
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Metallurgy
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155
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--Quenching
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109
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705
Residual
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115
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111
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Furnaces
109
Welding
Electric
heating
Diffusion
coatings
Shot
peening
Metal-
work
Electric
furnaces
Metal
spraying
840
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--Finishing
157
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116
Diffusion
158
--Terminology
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116
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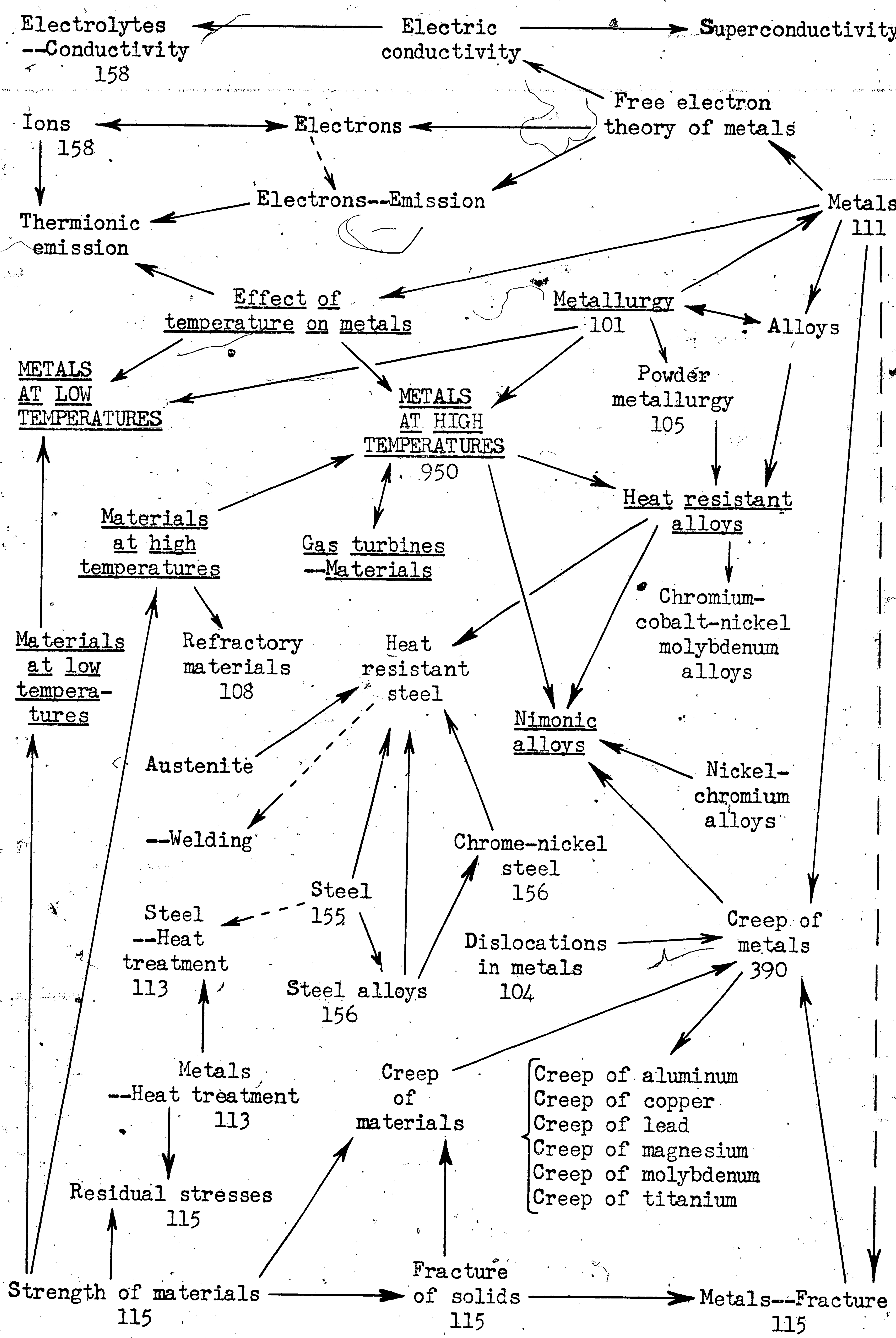
Metals
111
Aluminum coating
116
Also subdivision
"--Heat treatment"
under:
Aluminum alloys
Iron
Nonferrous metals
--Materials
--Tables, calculations, etc.


Electrolytes
--Conductivity
158
Electric
conductivity
Superconductivity
Free electron
theory of metals
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158
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Electrons--Emission
Thermionic
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METALS
AT HIGH
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105
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cobalt-nickel
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tempera-
tures
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113
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104
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156
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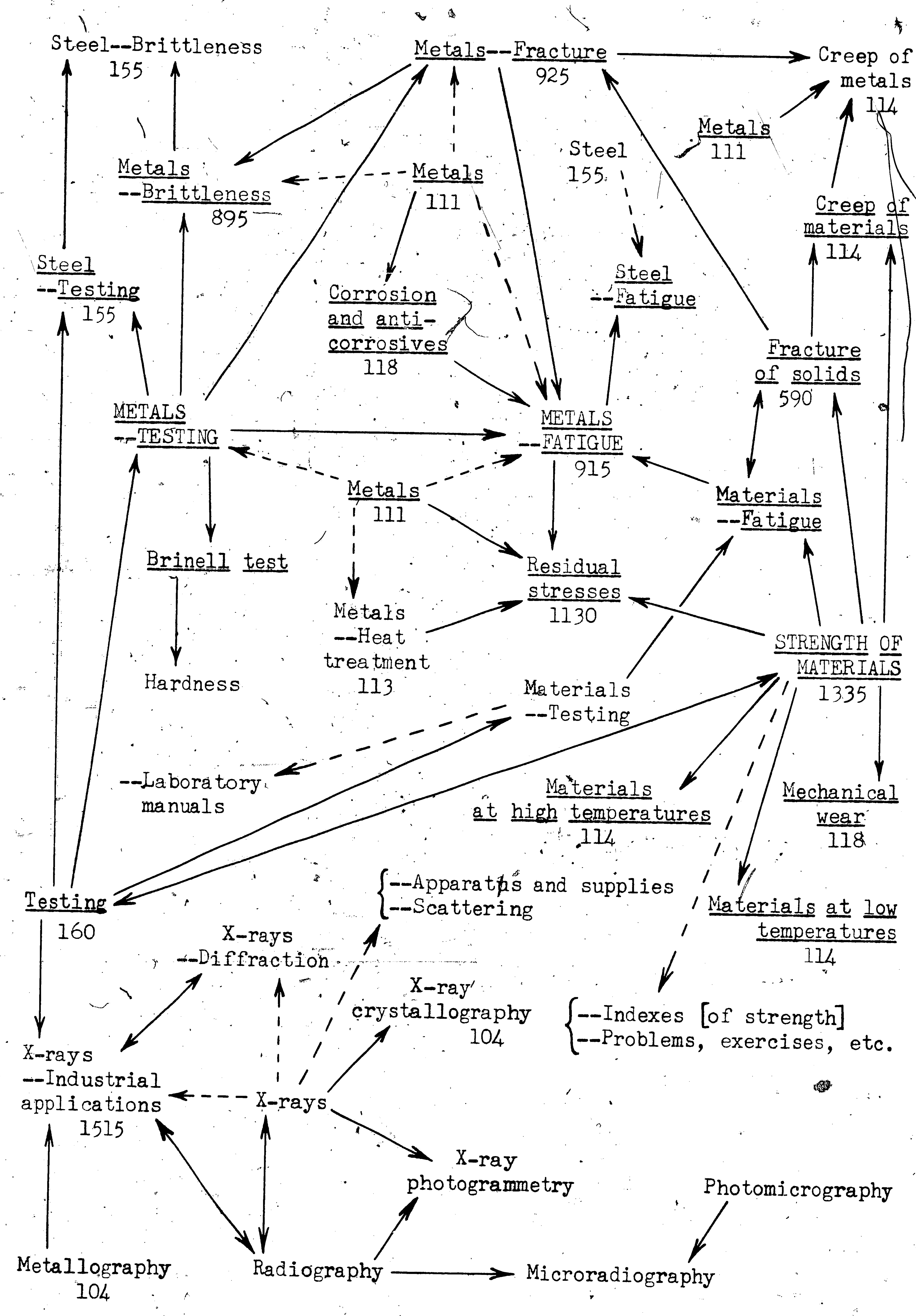
Steel--Brittleness 155
Metals--Fracture 925
Creep of metals 114
Metals 111
Steel 155
Metals --Brittleness 895
Metals 111
Creep of materials 114
Steel --Testing 155
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METALS --FATIGUE 915
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Residual stresses 1130
Metals --Heat treatment 113
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STRENGTH OF MATERIALS 1335
Materials --Testing
--Laboratory manuals
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--Apparatus and supplies
--Scattering
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--Problems, exercises, etc.
X-rays --Industrial applications 1515
X-rays
X-ray photogrammetry
Photomicrography
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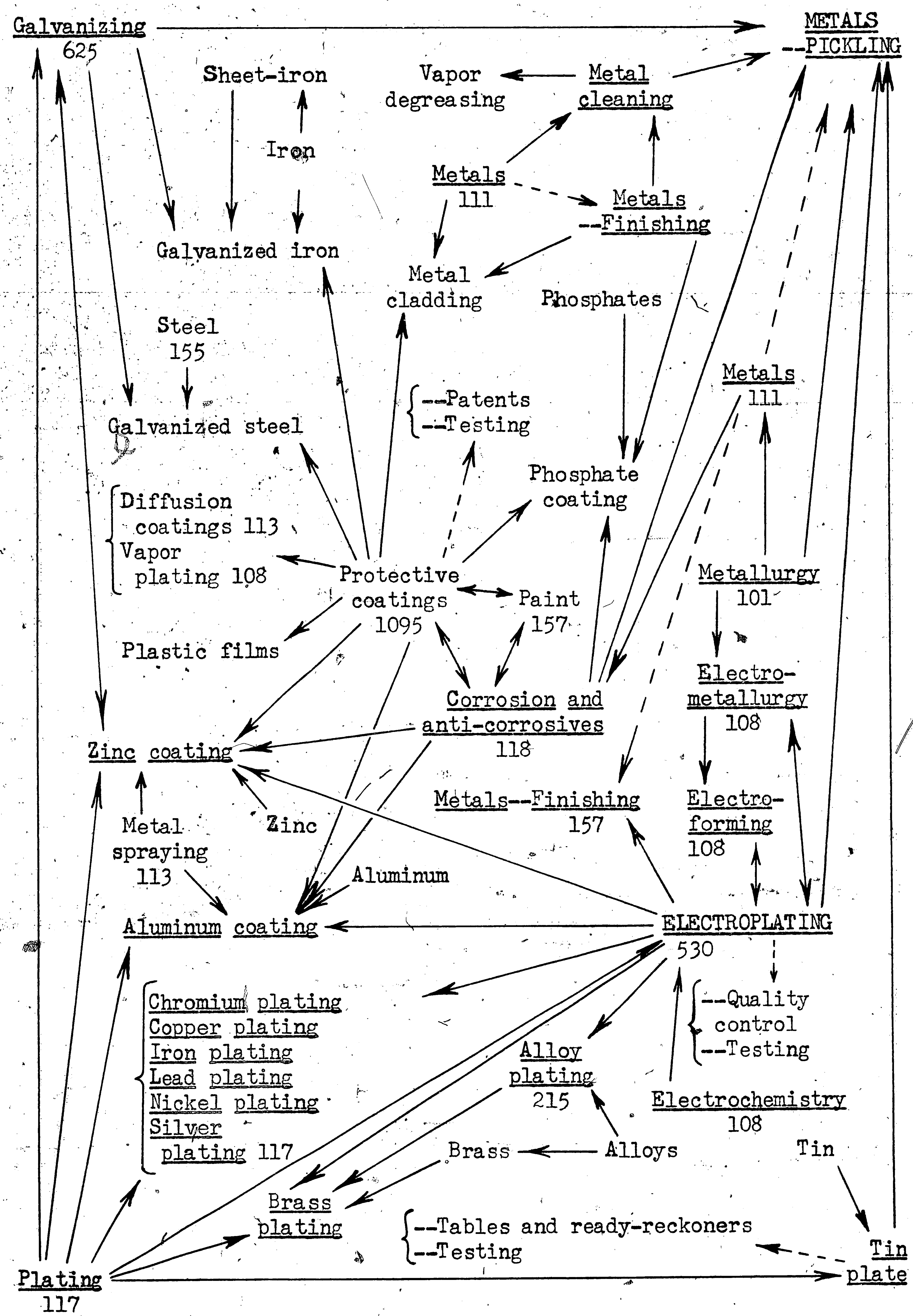
Microradiography


Galvanizing
625
METALS
--PICKLING
Sheet-iron
Vapor
degreasing
Metal
cleaning
Iron
Metals
111
Metals
--Finishing
Galvanized iron
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157
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101
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108
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118
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157
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215
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108
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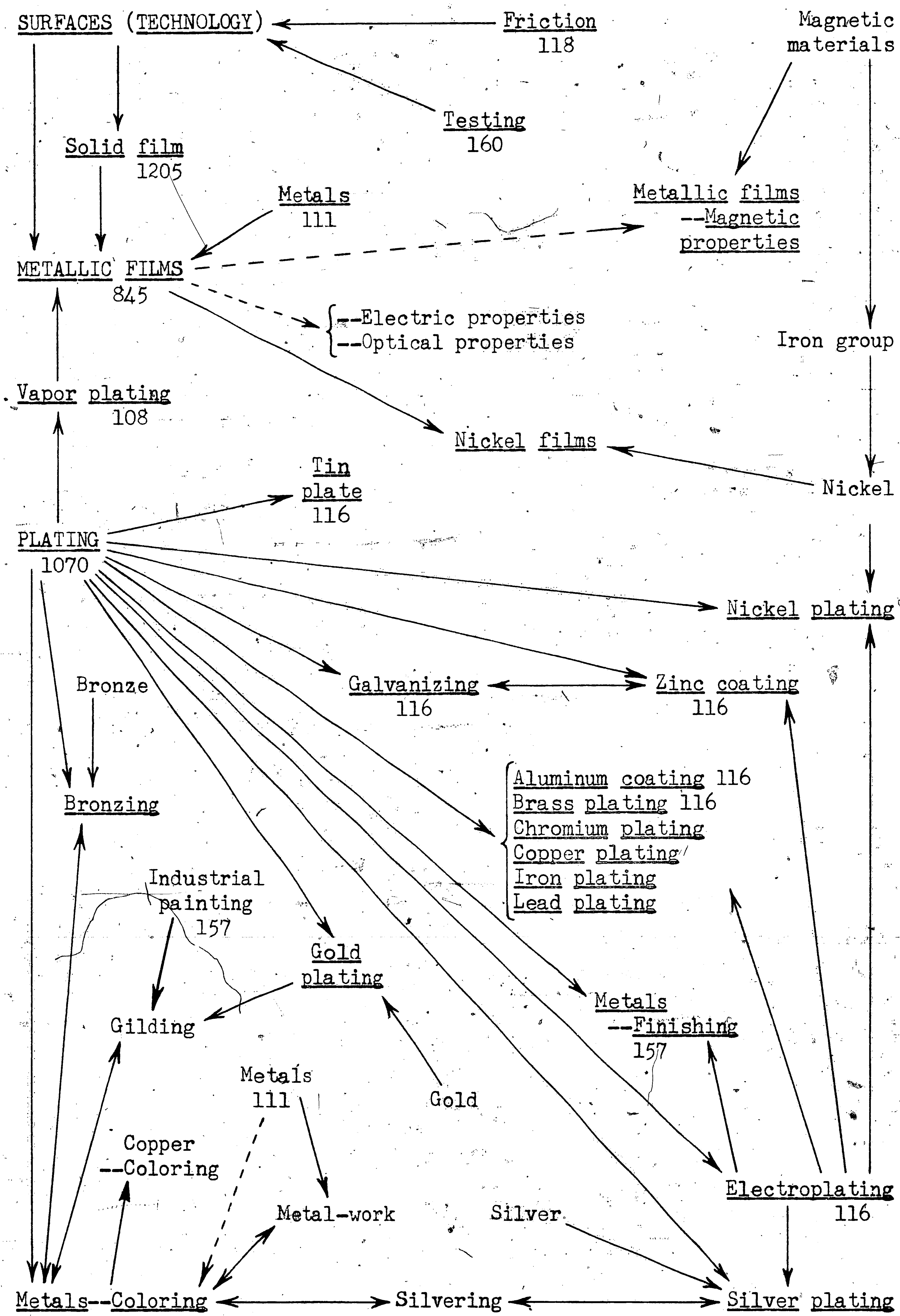
Brass
plating
--Tables and ready-reckoners
--Testing
Tin
plate
Plating
117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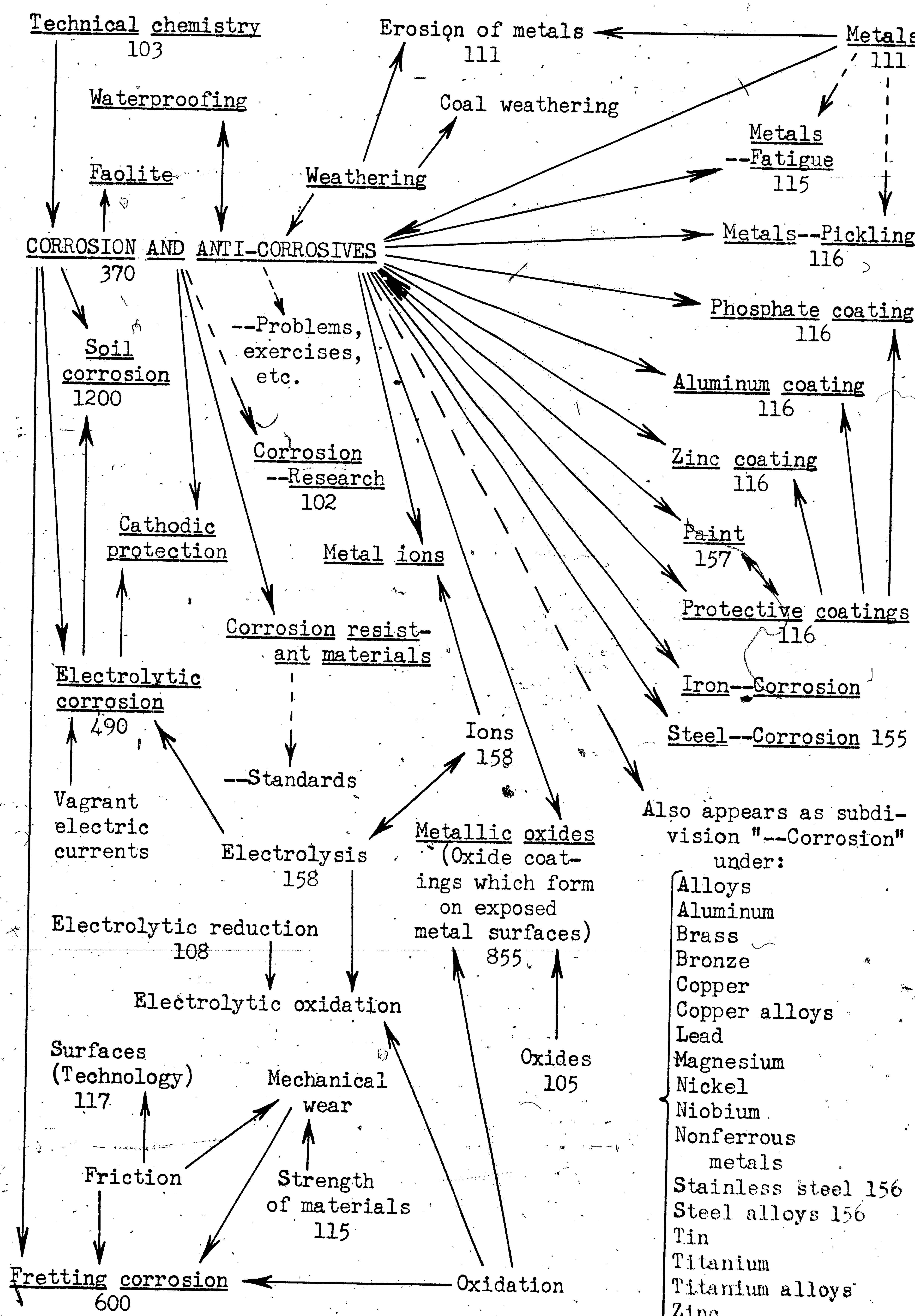
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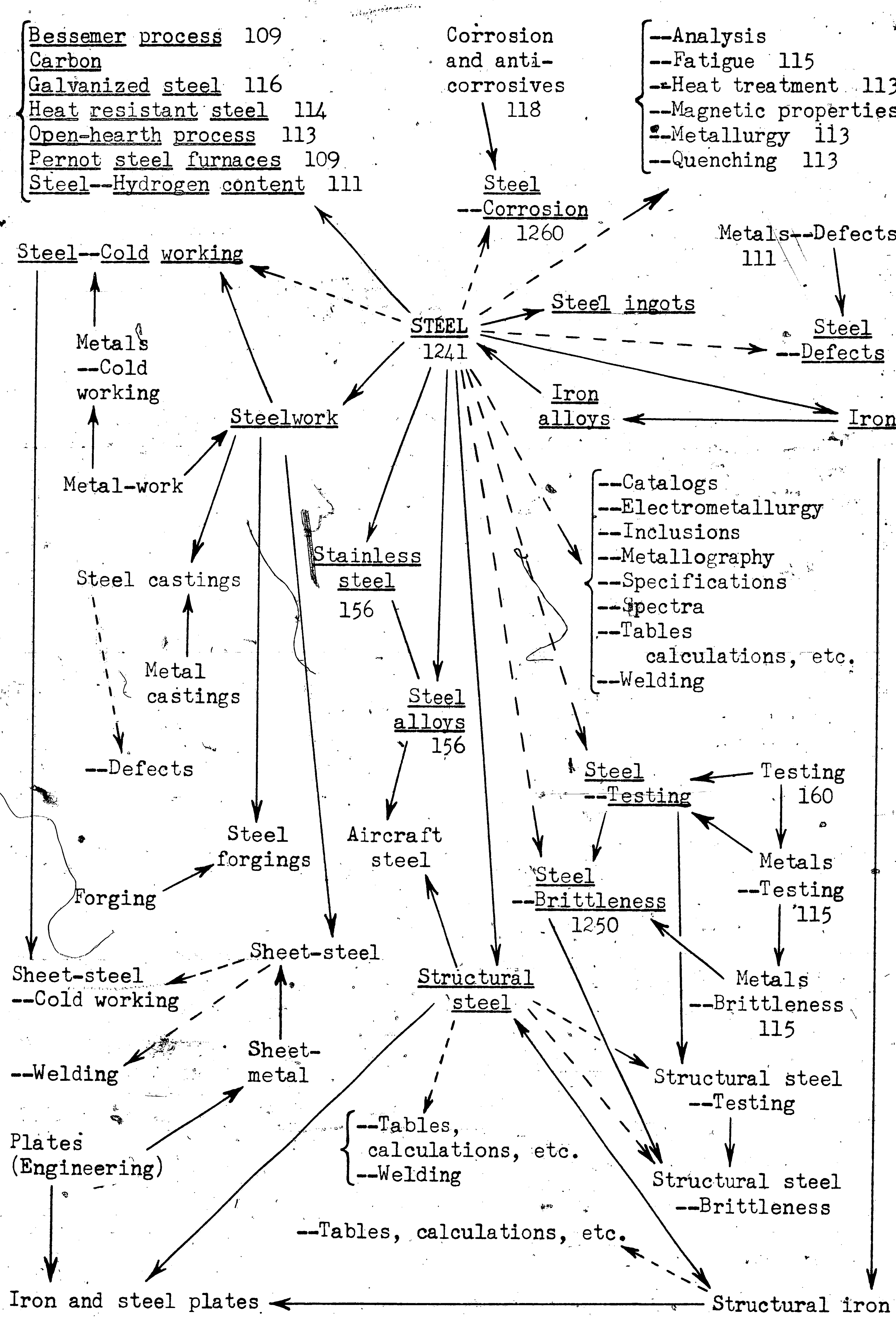
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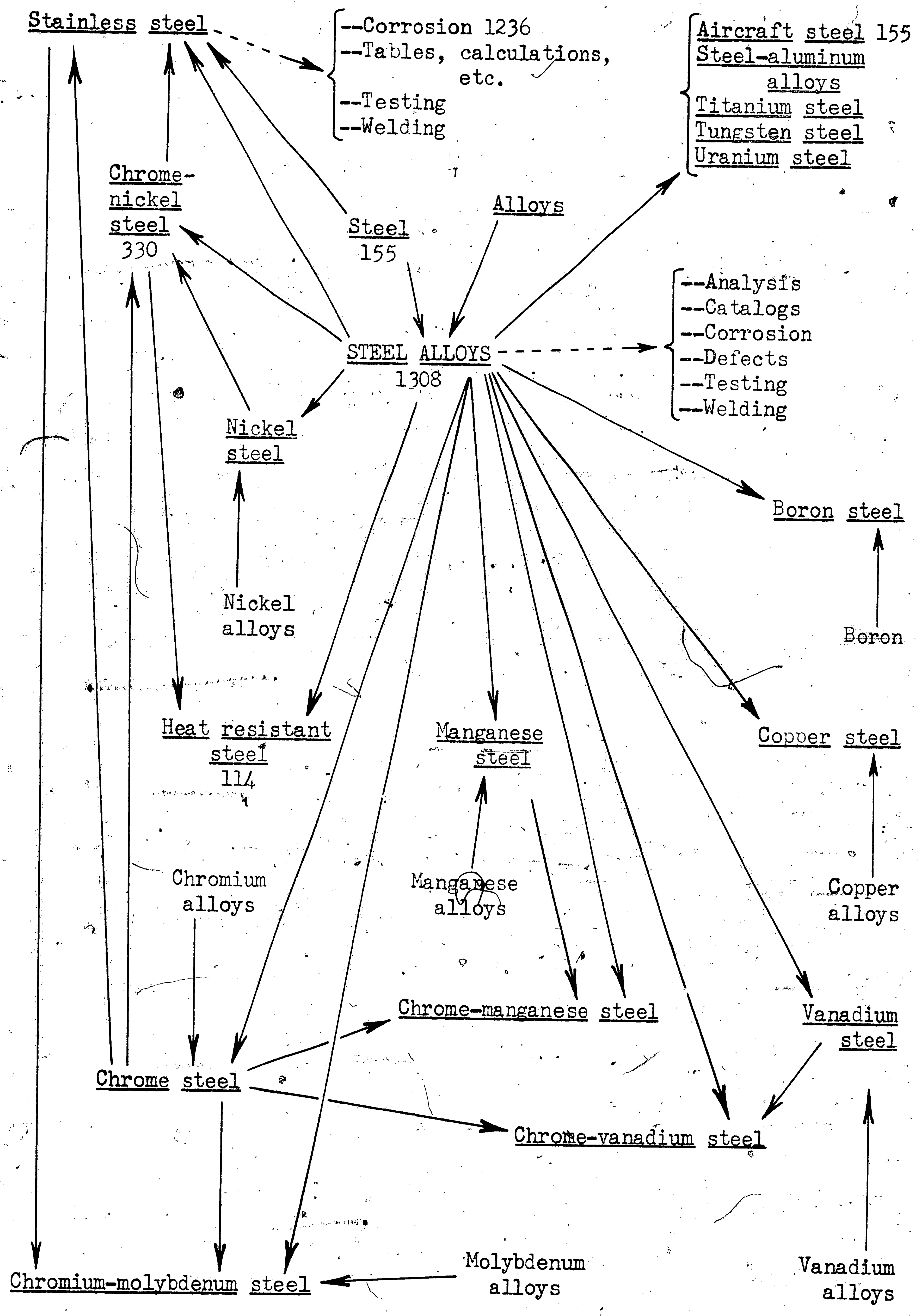
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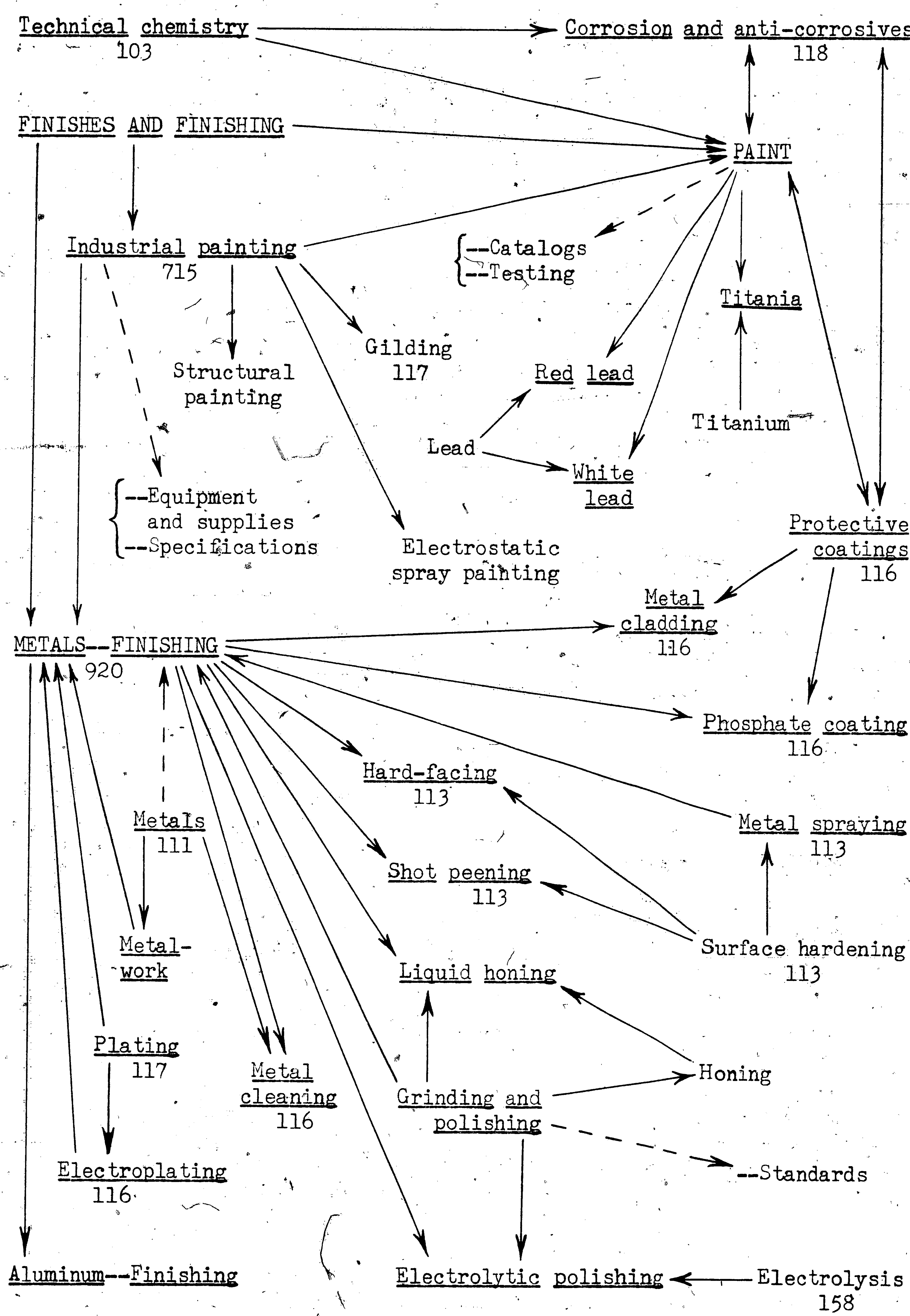
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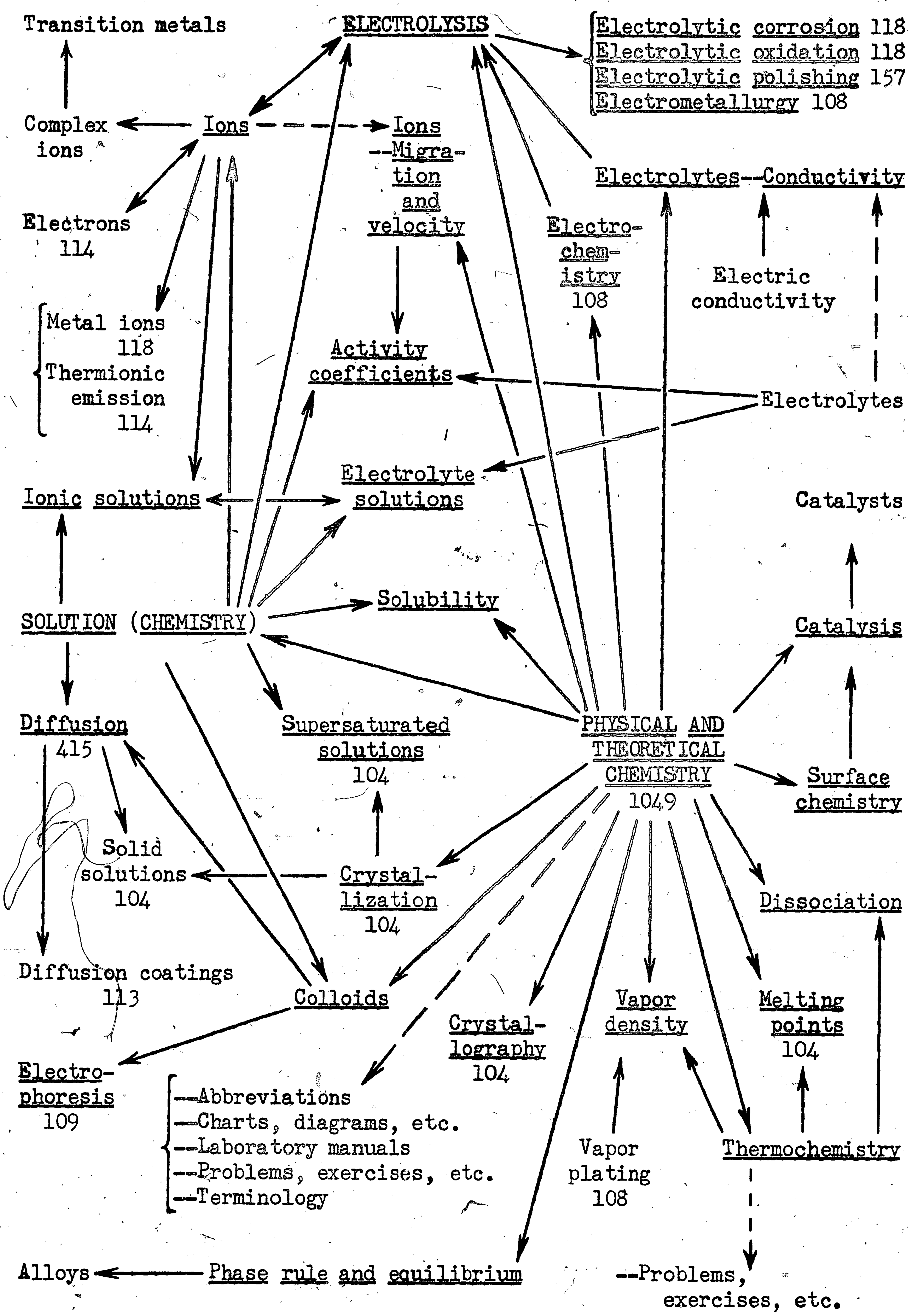
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CORROSION AND ANTI-CORROSIVES

Information Centers

National Association of Corrosion Engineers (S), 980 M & M Building, Houston, Texas, 77002

Established: 1943. Membership: 7,000. Purpose: to promote the prevention of corrosion; to provide forums and media for reporting on corrosion; to encourage study and research on corrosion; to correlate study and research among technical associations to reduce duplication; to promote standardization of terminology, techniques, equipment, and design; to collect, classify and disseminate corrosion control information from all over the world. Publications: Corrosion, monthly; Corrosion Abstracts, bimonthly; Materials Protection, monthly.

Indexes, Abstracts, Lists of Documents

Corrosion Abstracts, v.1- . Houston, Tex.: National Association of Corrosion Engineers, 1962- , bimonthly.

Incorporates the abstract section of Corrosion and the NACA Abstract Punch Card Service. Abstracts from several sources are arranged in a detailed classified order. Each issue also contains a detailed alphabetic subject index, indication page and line. All aspects are covered.

Serials

Corrosion, v.1- . Houston, Tex.: National Association of Corrosion Engineers, 1945- , monthly.

In January 1962 was divided, and its issues changed emphasis. Now contains exclusively scientific and engineering data on corrosion and its control. No longer limited to papers by association members. Cumulated indexes cover 1945-54 and 1955-59. Rest of journal appears as Materials Protection, v.1, 1962- .

Corrosion Science, v.1- . London: Pergamon, August 1961- , quarterly.

An international journal containing original papers, notes, and critical reviews on every aspect of corrosion science and materials protection. Published under the auspices of the Corrosion Science Society and the Centre Belge de l'Etude de la Corrosion, assisted by an international editorial board.

Materials Protection, v.1- . Houston, Texas; National Association of Corrosion Engineers, Inc., 1962- , monthly.

Mainly information on corrosion protection of materials; information areas formerly included in Corrosion, in which this periodical had its beginning; annual index.

CORROSION AND ANTI-CORROSIVES
(Continued)

General

Shreir, L. L., ed. Corrosion, 2vs. New York: Wiley, 1963. various paging.
Volume 1, Corrosion of Metals and Alloys: volume 2, Corrosion Control. More than 100 specialists. Emphasis on corrosion and its control in construction materials. These volumes are a major contribution to the literature of corrosion.
FRAME 1870

FRETTING CORROSION

Handbooks

DePaul, D. J. Corrosion and Wear Handbook. New York: McGraw-Hill (for Atomic Energy Commission), 1957. 293p.
Sponsored by Naval Reactors Branch of Atomic Energy Commission. Deals with use of water in nuclear reactor systems. Three parts contain: background information and general principles, tabulated data and detailed information for use as reference for actual design work, and material on special types of corrosion and application problems involving wear.

General

Forrest, P. G. Fatigue of Metals. Reading, Mass.: Addison-Wesley (Addison-Wesley Series in Metallurgy and Materials), 1962. 425p.
Many detailed charts, diagrams, tables, plates. Includes 30 pages of references.
FRAME 1782

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A symposium arranged and sponsored by Committee on Corrosion-Resistant Metals, Institute of Metals Division, the Metallurgical Society, and Pittsburgh Section, AIME. Presented in cooperation with the Electrochemical Society, National Association of Corrosion Engineers, and the ASTM, Pittsburgh, April 2-3, 1959.

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General

Forrest, P. G. Fatigue of Metals. Reading, Mass.: Addison-Wesley (Addison-Wesley Series in Metallurgy and Materials), 1962. 425p. illus.
Many detailed charts, diagrams, tables, plates. Includes 30 pages of references. FRAME 1780

Kennedy, A. J. Processes of Creep and Fatigue. New York: Wiley, 1963. 430p. illus.
An advanced treatment for physicists, metallurgists, and engineers. Includes fundamentals and bridges gap between engineering and metallurgical aspects. Many references.

Forrest, P. G. Fatigue of Metals. Reading, Mass.: Addison-Wesley, 1962.

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CORROSION OF METALS AND ALLOYS

Section 1. Principles of Corrosion and Oxidation

Section 2. Environments

Section 3. Ferrous Metals and Alloys

Shreir, Corrosion

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Shreir, Corrosion

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Section 12. Pretreatment and Design for Metal Finishing

Section 13. Methods of Applying Metallic Coatings

- FRAME 1873 -

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Section 14. Protection by Metallic Coatings

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Section 17. Miscellaneous Coatings

Section 18. Conditioning the Environment

- FRAME 1874

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Section 19. Non-Metallic Materials

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Forrest, Fatigue of Metals

TABLE 46. CORROSION FATIGUE DATA FOR FERROUS METALS

Material	Heat treatment	Tensile strength tons/in²	Type of fatigue stress	Frequency of stress cycles/min	Corrosive medium	Endurance basis for corrosion fatigue tests	Fatigue limit in air tons/in²	Corrosion fatigue strength tons/in²	Corrosion fatigue strength ÷ Air fatigue strength	Ref.
Mild steel 18/8/1 Cr, Ni, W steel	Normalized Annealed		R.B.		River Tees water drip feed	10^8	17·0 17·6	[2] 11·1	0·12 0·63	Inglis and Lake [372]
0·21% C steel	Annealed	31·8	R.B. T	1300 1500	Sea water	10^8	14·3 9·0	1·9 2·5	0·13 0·28	Hara [373]
12·5% Cr steel 18/8 stainless 18·5% Cr steel 0·48% C steel, Cd plated	Annealed	65 84 50 72	T	360	Fresh water	25×10^6	16·3 12·3 15·6 12·9	8·0 5·3 12·3 3·3	0·49 0·44 0·79 0·26	Haven [374]
C steel SAE 1035 (0·32–0·38% C)		39	R.B.	1750	(1) 6·8% salt solution (2) 6·8% salt solution sat. with H_2S specimens completely immersed	10^7	18·1	(1) 11·0 (2) 4·7	0·61 0·26	Wescott [375]
C steel SAE 1050 (0·48–0·55% C)		42					14·1	(1) 8·9 (2) 4·9	0·63 0·35	
C steel SAE 1050	Water-quenched and drawn	58					26·9	(1) 11·3 (2) 6·2	0·42 0·23	
Alloy steel SAE 4130 (0·8–1·1% Cr, 0·15–0·25% Mo)	Water quenched and drawn	57					31·3	(1) 12·0 (2) 6·3	0·38 0·20	
Alloy steel SAE 9260 (0·55–0·65% C, 1·8–2·2% Si)	Normalized	64					32·2	(1) 11·1 (2) 6·6	0·35 0·20	
5% Cr steel	Oil quenched and drawn	58					33·0	(1) 23·6 (2) 6·9	0·71 0·21	
Wrought iron		21					13·6	(1) 8·7 (2) 7·3	0·64 0·54	

Corrosion fatigue data for steels given protective treatments are given in Table 50
R.B. = Rotating bending
T = Torsion

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FRAME 2100

TABLE 48. CORROSION FATIGUE DATA FOR NON-FERROUS METALS

Material	Heat treatment	Tensile strength tons/in²	Type of fatigue stress	Frequency of stress cycles/min	Corrosive medium	Endurance basis for fatigue tests	Fatigue strength in air tons/in²	Corrosion fatigue strength tons/in²	Corrosion fatigue strength ÷ Air fatigue strength	Ref.
Aluminium	Annealed	5·6	R.B.	1450	(1) Fresh water (2) River water with saline content about ⅓ that of sea water	2 × 10⁷	2·7	— (2) 1·1	— 0·41	McAdam [378]
Aluminium	Half hard	7·1					3·2	— (2) 1·6	— 0·50	
Aluminium	Hard	9·1					4·7	(1) 2·7 (2) 2·2	0·57 0·47	
Duralumin	Annealed	14·9					7·8	(1) 3·6 (2) 3·3	0·46 0·42	
Duralumin	Heat treated	30·9					8·0	(1) 4·5 (2) 3·8	0·56 0·47	
Electrolytic copper, hot rolled	Annealed	13·9					4·5	(1) — (2) 4·7	— 1·04	
Electrolytic copper, cold worked	Tempered	20·8					7·6	(1) 7·8 (2) 7·8	1·03 1·03	
78% copper 21% nickel, cold worked	Annealed	21·1					8·0	(1) 8·5 (2) 8·5	1·06 1·06	
78% copper 21% nickel, cold worked	Tempered	27·8					11·6	(1) 10·7 (2) 11·6	0·92 1·0	
48% copper 48% nickel, cold rolled		38·2					17·0	(1) 13·0 (2) 14·7	0·76 0·86	
Monel 67% Ni 30% Cu, cold rolled	Annealed	36·5					16·1	(1) 12·0 (2) 13·0	0·75 0·81	
Monel 67% Ni 30% Cu, cold rolled	Tempered	56·7					23·6	(1) 13·8 (2) 15·6	0·58 0·66	
Nickel, cold rolled	Annealed	34·6					15·2	(1) 11·2 (2) 10·3	0·74 0·68	
Nickel, cold rolled	Tempered	58·7					23·2	(1) 13·4 (2) 12·0	0·58 0·52	
62% copper 37% zinc, cold drawn	Annealed	23·7					10·0	(1) — (2) 8·5	— 0·85	
62% copper 37% zinc, cold drawn	Tempered	37·5					10·7	(1) 8·0 (2) 8·0	0·75 0·75	
Duralumin	As rolled	28·2	R.B. Ax	2200	3% Salt spray	5 × 10⁷	9·2 6·7–9	3·4 2·6	0·37 0·33	Gough and Sopwith [369]
Magnesium 2·5% Al alloy	As rolled	16·4	R.B. Ax			10⁷	6·7 5·2–6	(1·0) 1·0	0·15 0·18	
Phosphor bronze 4·2% tin	Rolled and drawn normalized	27·6	R.B.	2200	3% Salt spray	5 × 10⁷	9·8	11·7	1·19	Gough and Sopwith [379]
Aluminium bronze 8·9% Al 1·4% Zn	Extruded and drawn	35·7					14·3	9·8	0·68	
Beryllium bronze 2·2% Be	Extruded and drawn	41·8					16·3	17·4	1·07	
Superston bronze 9·7% Al 5·0% Ni 5·4% Fe	As forged	51·7					22·7	14·6	0·64	

Aluminium bronze 9·3% Al	Quenched	36·8	R.B.	2200	3% Salt spray	5 × 10⁷	11·4	8·7	0·76	Sopwith [380]
Aluminium bronze 9·3% Al	Quenched and reheated	32·8					9·9	7·8	0·79	
Beryllium bronze 2·2% Be	Solution-treated	32·2					17·4	13·6	0·78	
Beryllium bronze 2·2% Be	Fully heat-treated	81·2					19·4	15·9	0·82	
Sand-cast copper alloys: High tensile brass	As cast									
50% alpha phase		32·4	R.B.	3000	3% Salt spray	100 × 10⁶	12	6·3	0·52	J. Stone & Co., London
30% alpha phase		36·8					10	5·3	0·53	
15% alpha phase		38·2					8·8	5·5	0·62	
5% alpha phase		39·1					6·4	4·3	0·67	
60% Cu 34% Zn		40·8					9·2	6·4	0·70	
Superston 40, 8% Al 12% Mn		44·1					16·5	9	0·54	
Superston 60, 8% Al 12% Mn		52·2					13·2	8·5	0·64	
Manganese bronzes: Parsons manganese bronze		33/35	R.B.		Salt spray	25 × 10⁶ in air	11·6	7·5	0·65	Manganese, Brass and Bronze Co., Ipswich
Immadium II		34/38				50 × 10⁶ in salt spray	*13·7	9·2	0·67	
Immadium V		40/44					10·7	10·5	0·98	
Immadium VI		45/50					13·0	8·0	0·61	
80% copper 10% Al 5% Ni 5% Fe		45/55				10⁸	20·9	10·8	0·51	
Aluminium–zinc–magnesium alloy, DTD 683	Solution treated	17·5	R.B.		3% salt solution liquid film	10⁷	9	4·5	0·50	Stubbington and Forsyth [381]
	Fully heat-treated	31·1					12·5	5	0·40	
	Overaged	27·3					11	5	0·45	
Wrought aluminium alloys: Al 3% Mg	Heat treated		R.B.	5000	3% Salt spray	20 × 10⁶	8·2	3·2	0·38	Sterner-Rainer [382] and Jung-Konig
Al 7% Mg	Heat treated			5000			(7)	3·2	(0·45)	
Al Cu Mg	Heat treated			5000			(11·4)	5·4	(0·47)	
Magnesium alloys: Mg–Al–Zn AZG					Tap water	20 × 10⁶	5·1	2·5	0·49	Beck [145]
Mg–Al–Mn AM 537					Tap water		5·0	3·4	0·68	
Mg–Al–Zn AZ 855					Tap water		9·5	3·5	0·37	
Mg–Al–Mn AM 503					3% salt water		3·6	1·3	0·36	
Mg–Al–Mn AZ M					3% salt water		9·9	(0·8)	(0·08)	
Pure lead			R.B.	1785	38% sulphuric acid, drip feed	40 × 10⁶	0·19	0	0	Mack [383]
Tellurium lead, 0·05% Te 0·06% Cu							0·27	0·18	0·67	
Antimonial lead, 1% Sb							0·38	0·33	0·86	
Storage battery lead, 9·4% Sb 0·4% Sn							0·91	0·83	0·90	

R.B. = Rotating bending
Ax. = Axial stress

TABLE 49. CORROSION FATIGUE STRENGTH OF NOTCHED AND UNNOTCHED SPECIMENS OF Cr Ni STEEL SAE 3140 (Dolan [389]) AND CAST IRONS (Collins and Smith [390])

Material and heat treatment	Type of stress	Type of specimen	Minimum diameter of specimen in.	Radius of hole or fillet in.	Tensile strength tons/in²	Frequency of stress cycle/min	Endurance basis for fatigue strengths	Fatigue strength tons/in²: In air	Fatigue strength tons/in²: In stream of tap water	Strength reduction factor K_f: Mechanical notch alone	Strength reduction factor K_f: Corrosion alone	Strength reduction factor K_f: Corrosion and mechanical notch
SAE 3140 (1·1–1·4% Ni 0·55–0·75% Cr) Hot rolled	T	Unnotched	0·32		51	1400	10^7	19·6	14·5		1·35	
		Hole	0·4	0·04				9·8	6·0	2·0		3·3
	R.B.	Unnotched	0·3		57			28·6	15·2		1·88	
		Hole	0·4	0·04				13·8	7·1	2·06		4·0
Quenched and tempered	T	Unnotched	0·28		72			25·0	14·5		1·73	
		Hole	0·38	0·036				13·4	8·9	1·87		2·8
	R.B.	Unntoched	0·3		74			40·2	5·8		6·9	
		Hole	0·4	0·04				13·8	4·0	2·90		10·0
Slightly alloyed ordinary grey cast iron	T	Unnotched	0·3		9·9	1750	5×10^7	4·9	3·5		1·40	
		Hole	0·4	0·04				3·6	3·6	1·36		1·36
	R.B.	Unnotched				1450		4·0	3·1		1·29	
		Hole						3·6	2·2	1·11		1·82
Ni Mo cast iron	T	Unnotched			23·8	1750		9·8	5·4		1·81	
		Hole						7·1	3·6	1·38		2·7
	R.B.	Unnotched				1450		9·4	3·6		2·6	
		Hole						6·2	2·2	1·52		4·3
Slightly alloyed Ni Cr Cu inoculated cast iron	T	Unnotched			20·5	1750		7·6	8·2		0·93	
		Hole						6·4	6·7	1·19		1·14
	R.B.	Unnotched				1450		9·0	7·1		1·27	
		Hole						7·6	6·7	1·18		1·34
Austenitic high Ni Cu Cr cast iron	T	Unnotched			14·1	1750		5·3	2·7		1·97	
		Hole						4·5	2·7	1·18		1·97
	R.B.	Unnotched				1450		5·3	2·7		1·97	
		Hole						3·1	1·8	1·71		2·9

T = torsion
R.B. = rotating bending

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TABLE 50. THE EFFECT OF SURFACE TREATMENTS ON THE CORROSION FATIGUE STRENGTH OF STEELS

All fatigue tests in rotating bending

Material	Tensile strength tons/in²	Surface treatment	Approximate thickness of protective layer in.	Frequency of stress cycles/min	Corrosive medium	Endurance basis for fatigue strength λ	Fatigue strength tons/in²		Corrosion fatigue strength tons/in²⁷		Source	Ref.
							Untreated	Treated	Untreated	Treated		
0·5% C cold drawn steel: as drawn normalized	64·6 43·1	Enamel		2200	3% salt spray	2 × 10⁷	24·5 16·4	22·8 17·2	3·5 4·0	10·8 11·2	Sopwith and Gough	392
as drawn normalized		Galvanizing	0·0019					24·7 14·8		23·2 16·6		
as drawn normalized		Sherardizing	0·0005					22·8 14·8		24·5 15·2		
as drawn normalized		Electrolytic zinc plating	0·00056					24·4 16·1		21·4 14·7		
as drawn normalized		Electrolytic cadmium plating	0·00052					22·8 15·2		18·9 13·7		
as drawn normalized		Electrolytic cadmium plating + enamel	0·0005					23·2 15·8		17·7 13·5		
as drawn normalized		Electrolytic cadmium plating + oil	0·0005					21·8 15·8		15·0 13·4		
as drawn normalized		Phosphate treatment + enamel						22·8 17·8		10·7 12·9		
as drawn		Aluminium spray	0·002					25·8		19·5		

as drawn		Aluminium spray + enamel	0·002					25·2		24·1		
Mild steel	25	Hot dipped soft solder	0·0004		Fresh water drip feed	10^8	14	16·5	7	9	Cazaud	116
		Hot dipped cadmium coating	0·0008					14·5		11		
		Electroplated nickel	0·008					10		10		
		Electroplated chromium	0·008					14·5		14·5		
Mild steel	26·2	Surface rolling			Fresh water		16·5	18·5	6·5	9·5	Thum and Ochs	116
Medium carbon steel		Surface rolling	0·02		Fresh water	2×10^6	18·5	23	<10	19	Foppl	116
Nitralloy 1·6% Cr 0·9% Al 0·3% Mo steel		Nitriding			River water drip feed	10^8	33	37	<5	25	Inglis and Lake	372
SAE 6120 0·7–0·9% Cr 0·1% V steel	55	Nitriding		1450	Stream of tap water	10^8		47		38	Dolan and Benninger	393
0·47% C steel	47	Galvanizing			Fresh water	2×10^7	27		9	19·5	Harvey	394
		Sherardizing								19·5		
		Zinc plating								22		
		Cadmium plating								20·5		
0·38% C steel		Bright zinc plating	0·0005		Complete immersion in oil well brine saturated with hydrogen sulphide	10^7	25·2		5·4	8·8	Wescott	395
			0·001							10·2		
		Ductile zinc plating	0·0005							8·5		
			0·001							8·9		
SAE 4620 1·65–2% Ni 0·2–0·3% Mo steel		Nickel plating	0·005				23·4	17·9	10·0	15·6		
0·4% C 0·2% Cu steel		Zinc plating	0·0023				18·3		4·9	11·2		

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TABLE 51. THE EFFECT OF SURFACE TREATMENTS ON THE CORROSION FATIGUE STRENGTH OF NON-FERROUS METALS

All fatigue tests in bending

Material	Tensile strength tons/in²	Surface treatment	Approximate thickness of protective layer in.	Frequency of stress cycles/min	Corrosive medium	Endurance basis for fatigue tests	Fatigue strength in air tons/in² Untreated	Fatigue strength in air tons/in² Treated	Corrosion fatigue strength tons/in² Untreated	Corrosion fatigue strength tons/in² Treated	Corrosion fatigue strength—treated ÷ Fatigue strength in air—untreated %	Refs.
Duralumin	24–27	Anodizing		2000	3% salt spray	50×10^6	9·0	11·0	3·0			Gerard and Sutton [396]
		Anodizing + synthetic resin varnish (stoved)								9·5	105	
		Synthetic resin varnish only (stoved)								5·7	63	
		Zinc plating	0·0005							6·4	7[illegible]	
		Cadmium plating								2·5	28	
		Aluminium spraying	0·003							4·8	53	
Aluminium alloy (0·61% Mg, 0·94% Si)		Anodizing + hot water sealing		5000	(1) Tap water (2) 3% salt solution	10^8	8·0	7	(1) 4 (2) 2	(1) 7 (2) 6	87 75	Inglis and Larke [397]
		Anodizing + sealing in Pot. Dichromate						7		(1) 6 (2) 6·5	75 81	
		Painting						8·5		(1) — (2) 8·5	— 106	
Magnesium alloy (3% Al, 1% Zn)		Anodizing			Salt spray	10^7	5·9	4·1		4·5	76	Bennett [398]

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TABLE 52. RESISTANCE TO ACTION OF FRETTING CORROSION (McDowell [413])

Poor	Average	Good
Aluminium on cast iron	Cast iron on cast iron	Laminated plastic on gold plate
Aluminium on stainless steel	Copper on cast iron	Hard tool steel on tool steel
Magnesium on cast iron	Brass on cast iron	Cold rolled steel on cold rolled steel
Cast iron on chrome plate	Zinc on cast iron	Cast iron on cast iron with phosphate coating
Laminated plastic on cast iron	Cast iron on silver plate	Cast iron on cast iron with coating of rubber cement
Bakelite on cast iron	Cast iron on copper plate	Cast iron on cast iron with coating of tungsten sulphide
Hard tool steel on stainless	Cast iron on amalgamated copper plate	Cast iron on cast iron with rubber gasket
Chrome plate on chrome plate	Cast iron on cast iron with rough surface	Cast iron on cast iron with Molykote lubricant
Cast iron on tin plate	Magnesium on copper plate	Cast iron on stainless with Molykote lubricant
Cast iron on cast iron with coating of shellac	Zirconium on zirconium	
Gold plate on gold plate		

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FRAME 2107

END OF REEL:

REWIND

You should not be reading this frame. Index: FRAME 51; Instructions: 2.

REFERENCES

[1]Robert W. Cawley, "Report of Panel One: Objectives," in R. S. Taylor (ed.), Information Management in Engineering Education, Lehigh University, Bethlehem, Pa., 1966, pp. 23-24. Quotations are from p. 23.

[2]Victor Rosenberg, "The Application of Psychometric Techniques to Determine the Attitudes of Individuals Toward Information Seeking," Studies in the Man-System Interface in Libraries, Report no. 2, Lehigh University, Bethlehem, Pa., 1966, 46p.

[3]Rosenberg, p. 19.

[4]Cawley, in Taylor, p. 24.

[5]"Recommendations: Objectives Panel," in Taylor, p. 8. Refer to pp. 25-35 for details.

[6]See works by the following authors (listed in the bibliography to this paper) for detailed information regarding programmed instruction: John W. Howard (experimental scrambled text); Center for Applied Linguistics (bibliography); and Paul R. Wendt et al. (evaluative study). Also see Videosonic Systems Division, "VIDEOSONIC Systems," Videosonic Systems Division, Hughes Aircraft Company, Fullerton, Calif., n.d., and Harriett Genung, "Can Machines Teach the Use of the Library?" College & Research Libraries, 28 (1), January, 1967, 25-30, which is a report on the use of such a system to teach the use of the library by programmed instruction.

[7]From: U.S. Library of Congress, Subject Cataloging Division, Subject Headings Used in the Dictionary Catalogs of the Library of Congress, 6th ed., U.S. Library of Congress, Washington, D.C., 1957; plus January 1956 - December 1960 Supplements to the 6th Edition, January 1961 - June 1964 Supplements Included in the 7th Edition, and July-December 1964 Supplement to the 7th Edition (together henceforth referred to as the LC-List).

[8]This mode of display is very similar to that used in the European Atomic Energy Community, Center for Information and Documentation, Euratom-Thesaurus, European Atomic Energy Community, Brussels, 1964, pp. 37-79.

[9]See note 7 above. The Seventh Edition, which included the supplements through June, 1964, finally appeared in 1966.

[10] See D. J. Haykin, Subject Headings: A Practical Guide U.S. Library of Congress, Washington, D.C., 1951, pp. 89-90.

[11] Actual LC-List headings will appear entirely in upper case letters.

[12] Haykin, p. 91.

[13] Haykin, pp. 89-90.

[14] Italics, etc., as actually appearing in the LC-List.

[15] For further commentary on the shortcomings of subject-heading lists, see V. Mostecky, "Study of the See-Also Reference Structure in Relation to the Subject of International Law," American Documentation, 7 (October, 1956), 294-314. The investigator follows Mostecky's suggestion of a "chart" form of display for the cross-reference structure (pp. 304-313); but suggestions regarding changes in the structure itself (ibid) are not followed because the possibility of comparison of the proposed system with the existing subject catalog would be lessened thereby. However, the investigator wishes to stress that Mostecky's remarks, if taken as intended (as suggestions for improving subject catalogs in general), are eminently worthy of attention.

[16] That is, "sa" for "see also," "xx" for "see also from," "s" for "see," "x" for "see from," "nu" for "note under," plus one other to be described later. "--" is used in the LC-List to indicate subdivisions of a heading.

[17] Here upper-case spelling indicates boldface, while underscoring indicates italics, as actually found in LC-List entries.

[18] Note the new grouping and the elimination of the general reference, "also subdivision...."

[19] The appearance of these examples exactly matches the format of the 5x8 cards.

[20] Cross-references to headings outside the scope of the field of Metallurgy (loosely interpreted for completeness) were not recorded on the cards.

[21] For this purpose the investigator referred to the following chemistry and materials science texts, respectively: Michell J. Sienko and Robert A. Plane, Chemistry, McGraw-Hill, New York, 1957, 621p.; and Carl A. Keyser, Materials of Engineering, Prentice-Hall, Englewood Cliffs, N. J., c1956, 502p.

[22]Since all of the necessary data is already available on the 5x8 cards, provision has been made for ultimate inclusion of the rest of Metallurgy in the network system.

[23]The statistics below this frame number may be interpreted as follows: FRAME 101 exhibits headings on three levels, A, B, and C. At least one heading is complete (see text) on levels A, B, and C; but only those headings checked have this frame as master.

[24]Note that no "see" references appear on the maps; they are listed in the index only. Also note that the index, being alphabetical, is the only part of the system that need be greatly revised if the rest of Metallurgy were to be included, for, as has already been mentioned, the maps themselves are based upon the full original list of 840 productive headings, and random frame access solves all ordering problems. The original hard copy frames would simply be re-microphotographed after the frame numbers had been inserted for headings which previously had no master-frame.

[25]Eleanor B. Gibson and Elizabeth W. Tapia (ed.), Guide to Metallurgical Information (SLA Bibliography no. 3), 2nd ed., Special Libraries Association, New York, 1965, 222p.

[26]For further commentary regarding browsing, refer to the "General Remarks" section of this paper.

[27]See Videosonic Systems Division, VIDEOSONIC Systems, Videosonic Systems Division, Hughes Aircraft Company, Fullerton, Calif., n.d. For commentary on this system in use, see the Genung article (note 6, above).

[28]Videosonic Systems Division, op cit.

[29]Recordak Corporation. The Recordak Lodestar Magazine Loading Film Reader, Publication A-902 20M 3-59, 1959; Recordak Lodestar Reader-Printer, Publication A-985 5M 11-61, 1961; Recordak Automated Information Retrieval, Publication FSR 3-300-862, 1962; Recordak Image Control Keyboard, Publication A-987B 10M863(MM/PM), 1963. Recordak Corporation, New York.

[30]Howard W. Hoadley, A Rapid, Compact, Automatic Retrieval-Display System, Publication Q-103-66, Houston Fearless Corporation, Los Angeles, California, 1966, pp. 3-4. Quotations are from p. 3.

[31]U.S. Library of Congress, Information Systems Office, A Preliminary Report on the MARC (MAchine-Readable Catalog-

ing) Pilot Project, U.S. Library of Congress, Washington, D.C., 1966, 101p.

32 See Haykin, *op. cit.*

33 See n. 8, above.

34 Armed Services Technical Information Agency, *Thesaurus of ASTIA Descriptors*, 2nd ed., Armed Services Technical Information Agency, Arlington, Va., 1962, 673p.

35 Engineers Joint Council, *Thesaurus of Engineering Terms*, Engineers Joint Council, New York, 1964, 302p.

36 American Society for Metals, Committee on Literature Classification, *ASM-SLA Metallurgical Literature Classification, International (2nd) ed.*, American Society for Metals, Cleveland, Ohio, 1958, 74p.

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